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INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

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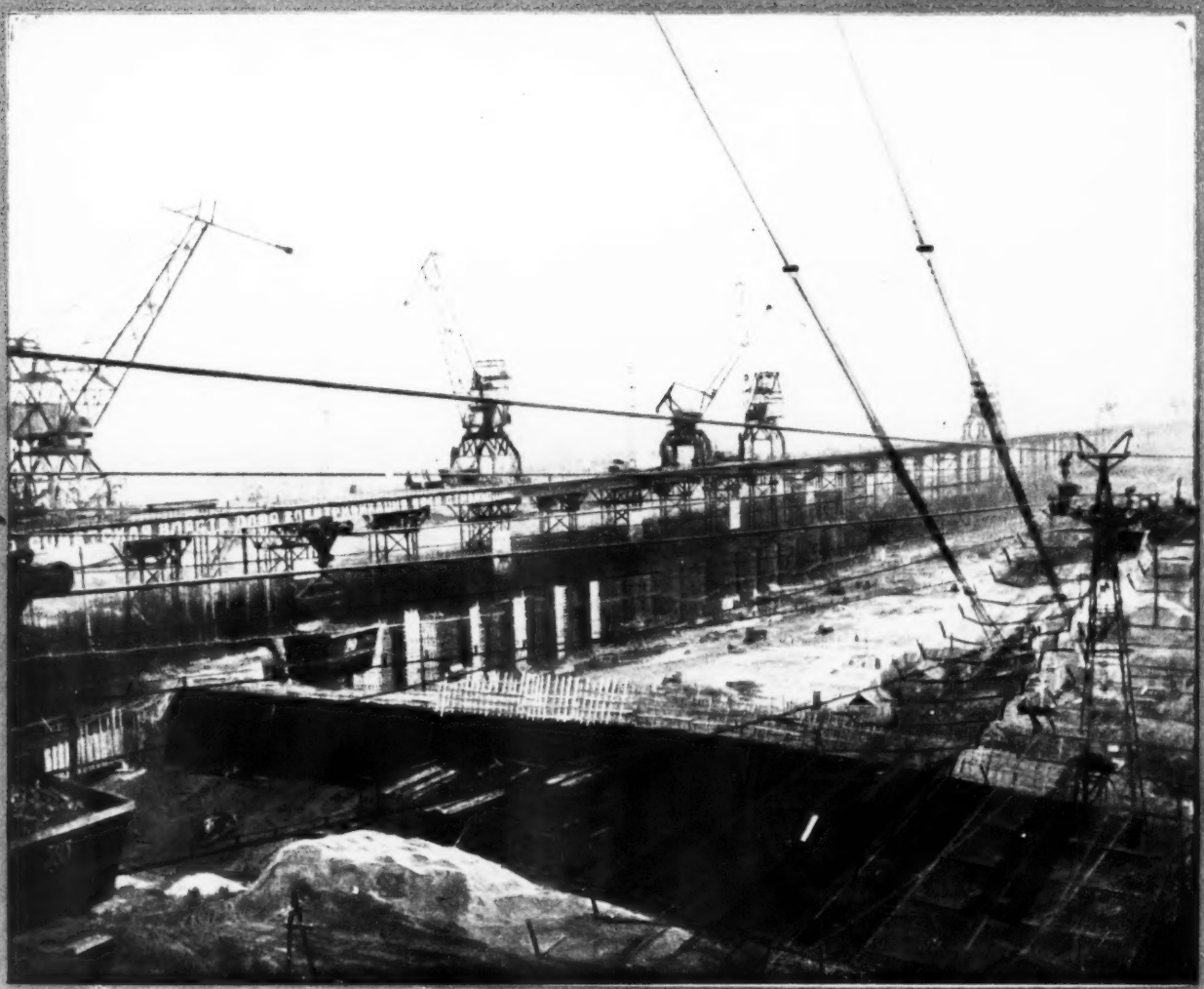

STALINGRAD HYDRO-ELECTRIC STATION UNDER CONSTRUCTION

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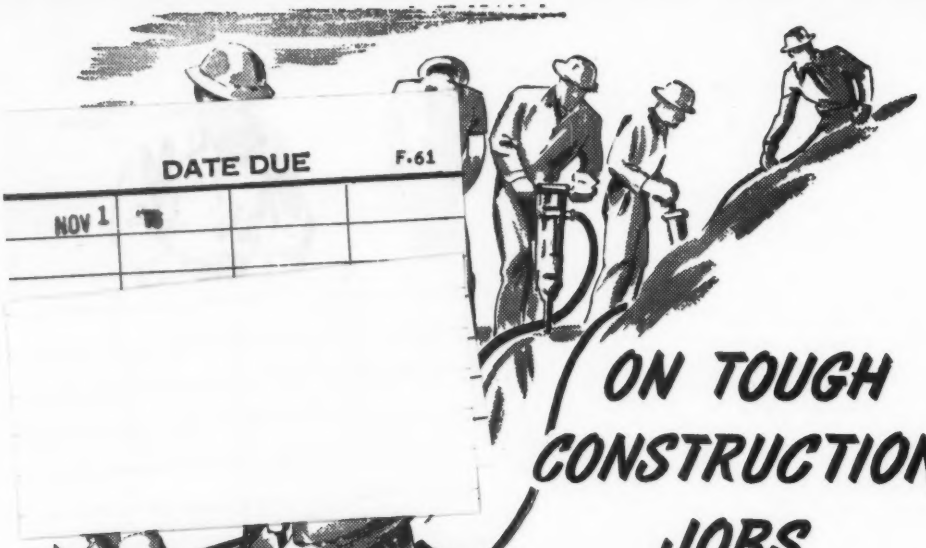

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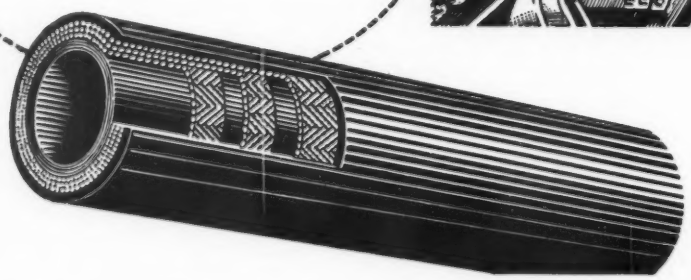

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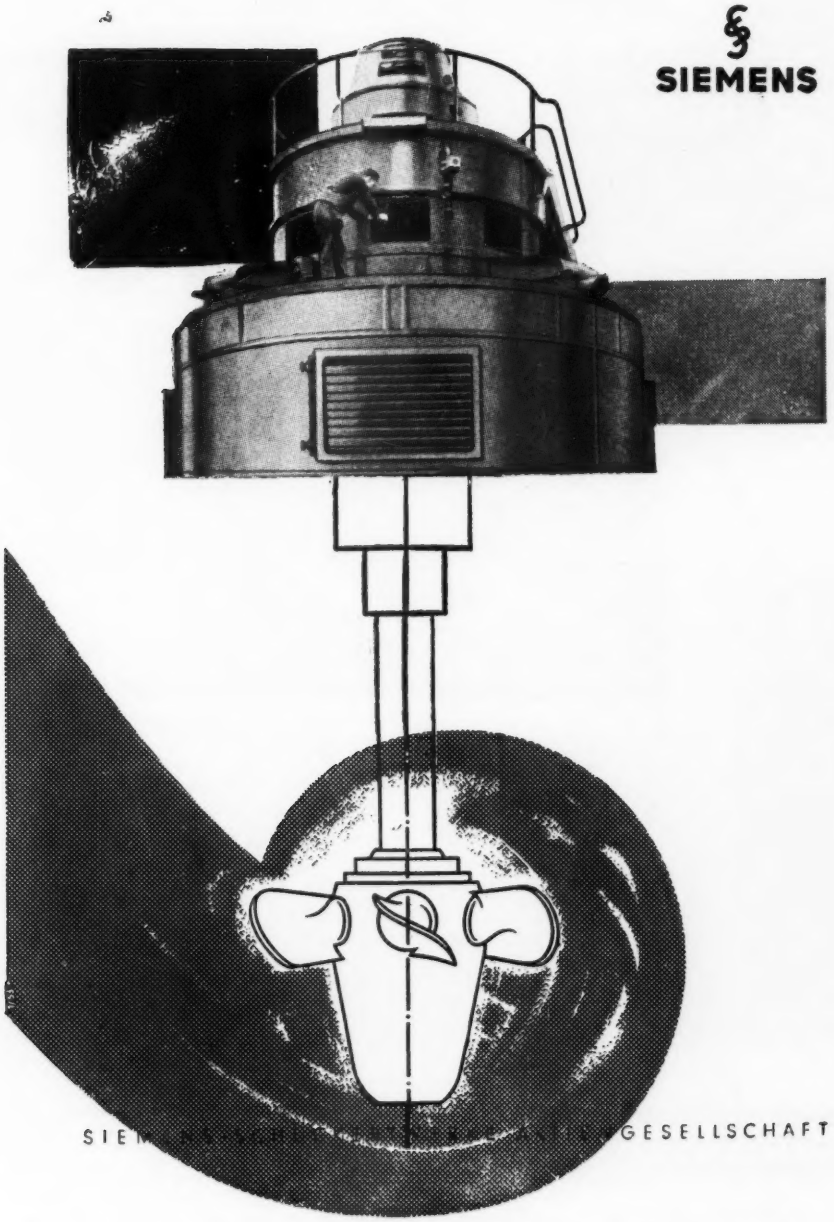
"Help the Red Cross to help the helpless"



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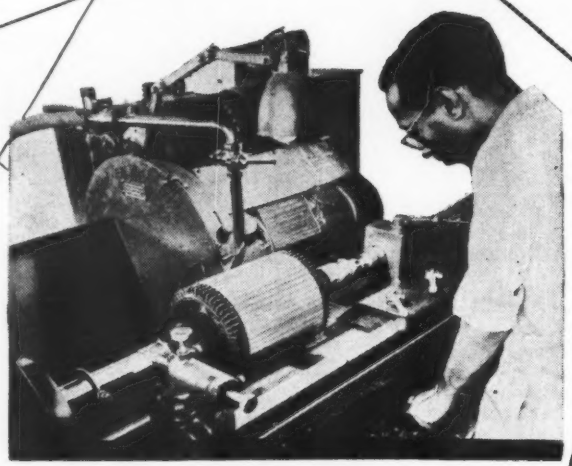

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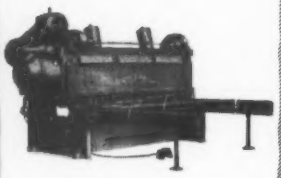

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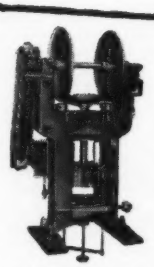
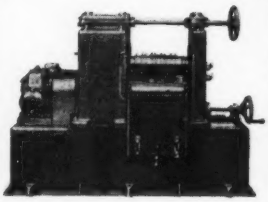
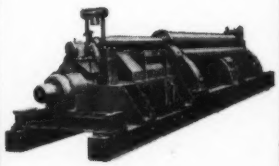


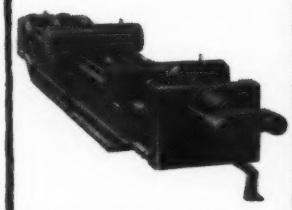
Friction Screw Press



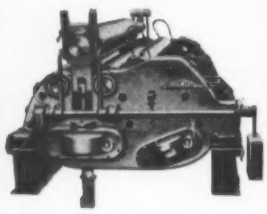
Gang Slitting Machine



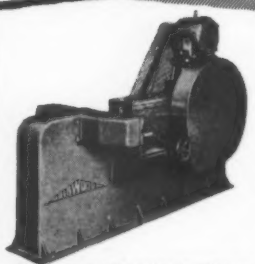
3-Roll Plate Bending Machine



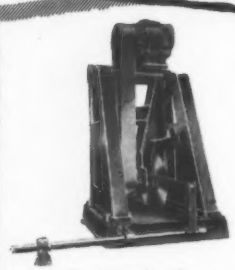
Hydraulic Stretching Machine for Sheets



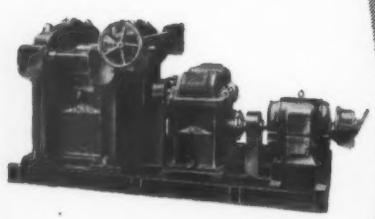
4-Roll Plate Bending and Straightening Machine



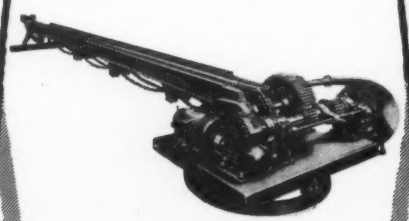
Bending and Straightening Press



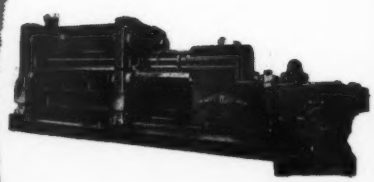
Pendulum Hot Saw



Bar Reeling Machine



Swinging Draw Bench for Tubes



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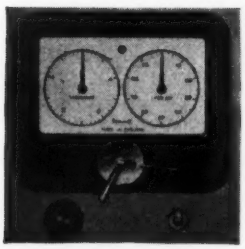

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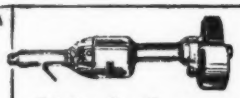
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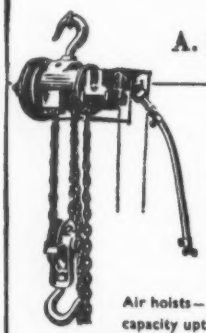
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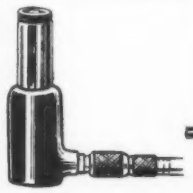
Holders-on – Different capacity

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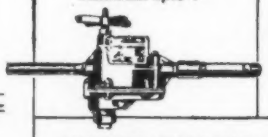
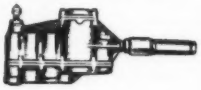


Close Corner Drills. Different capacity – upto 3"



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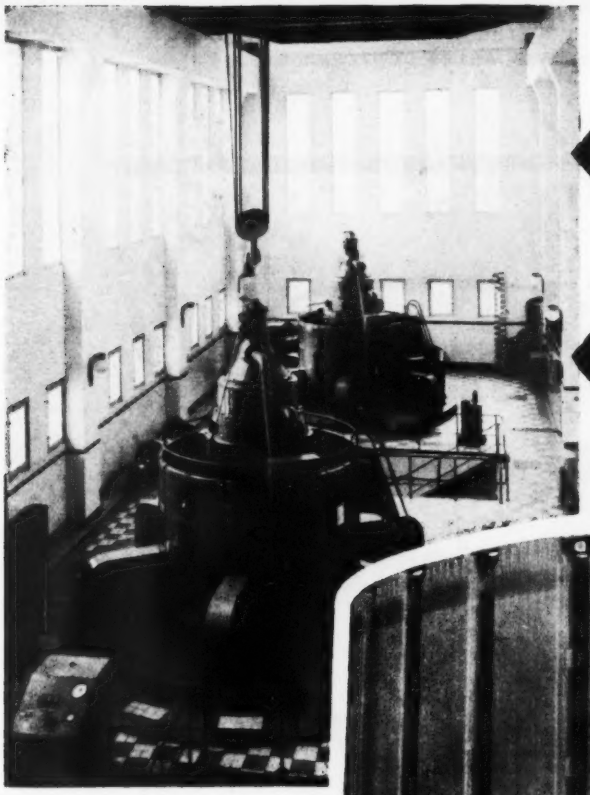

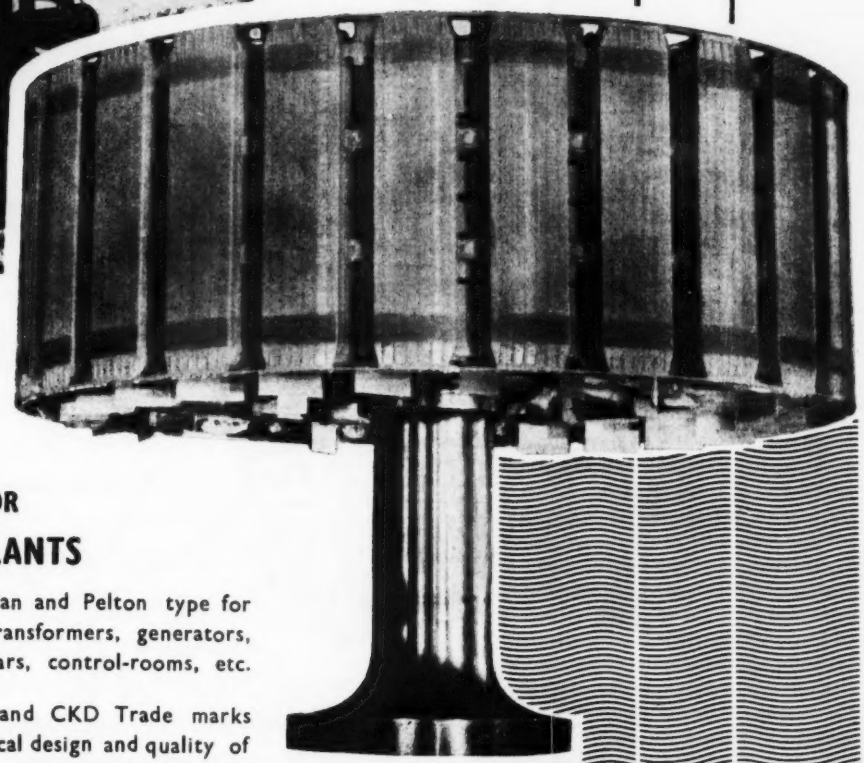

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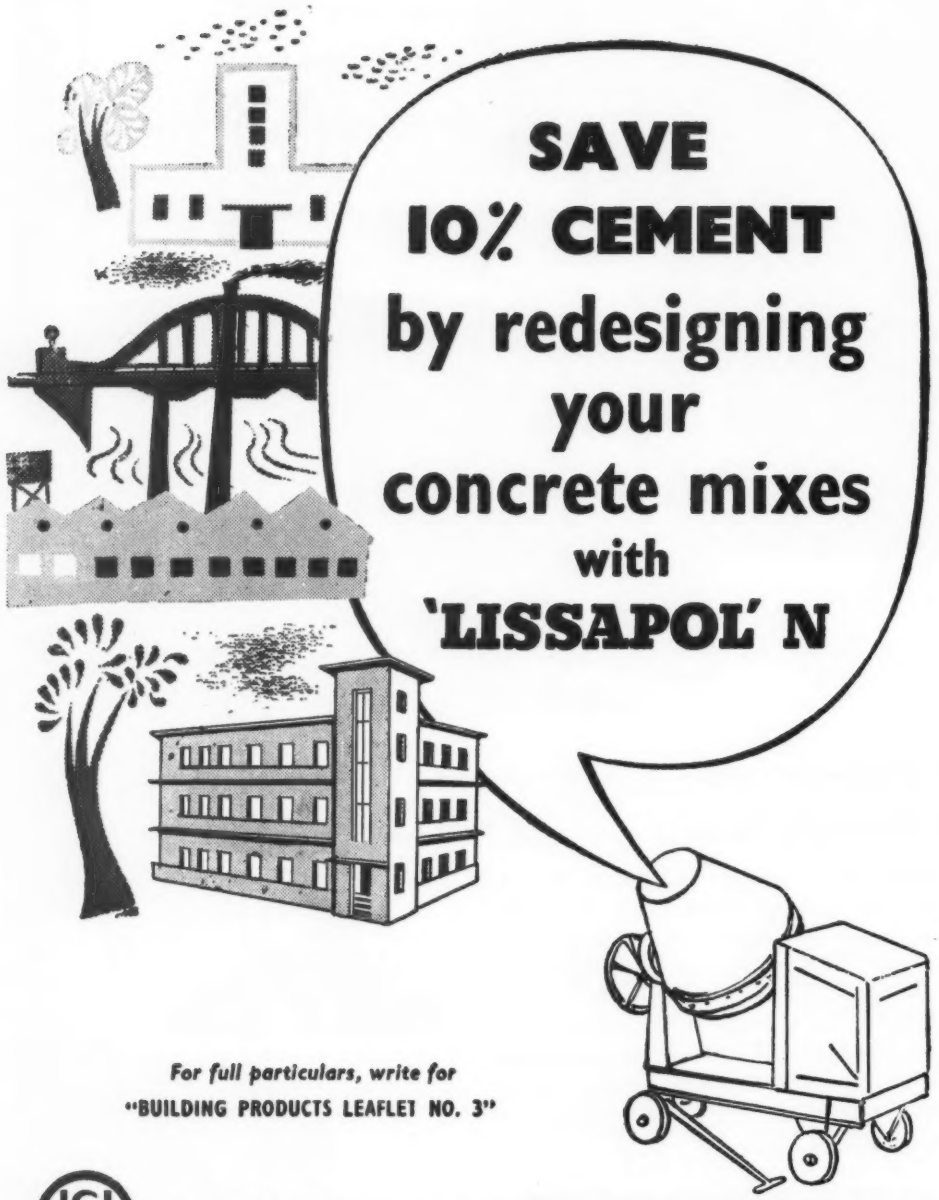

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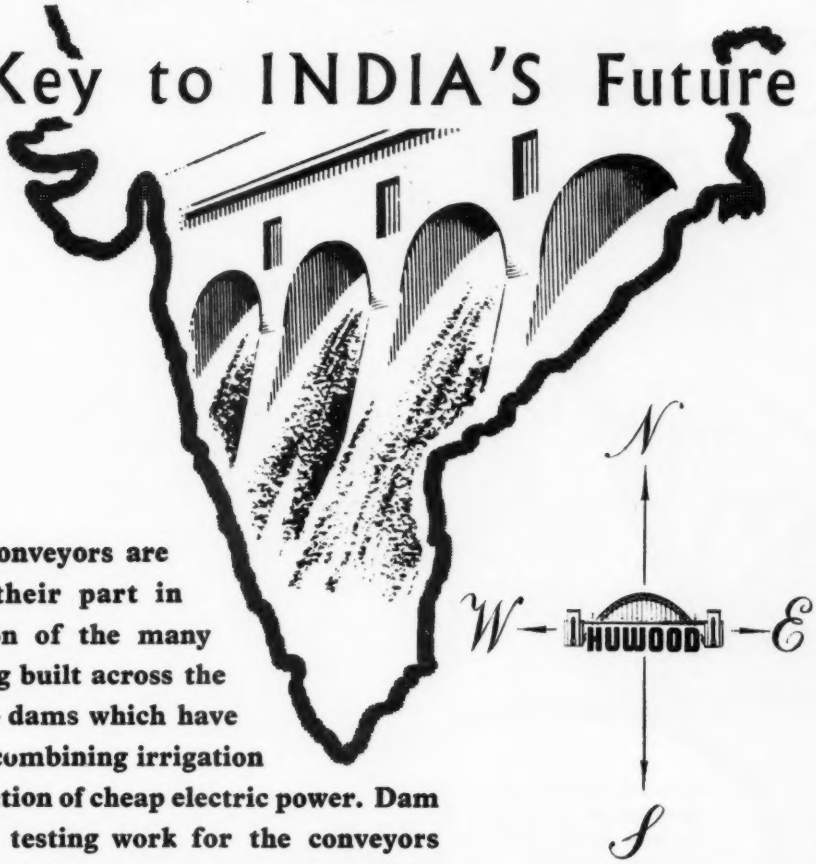

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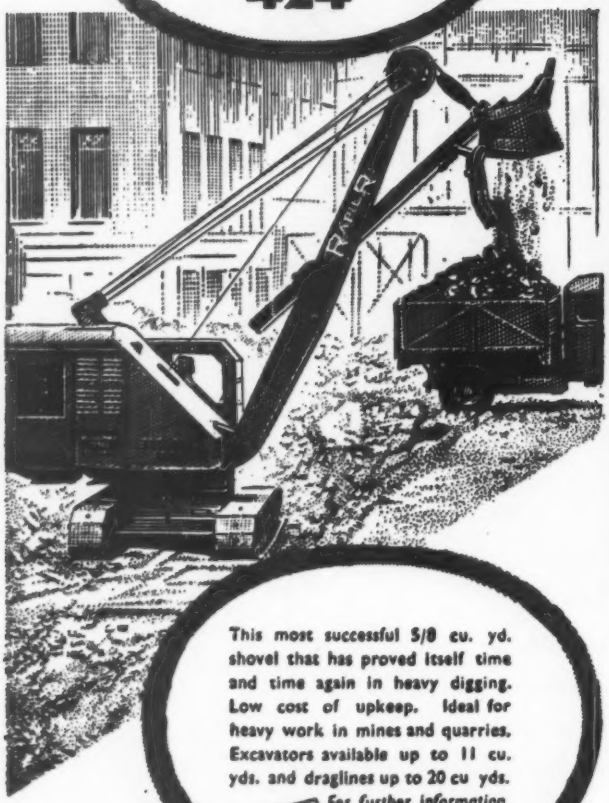

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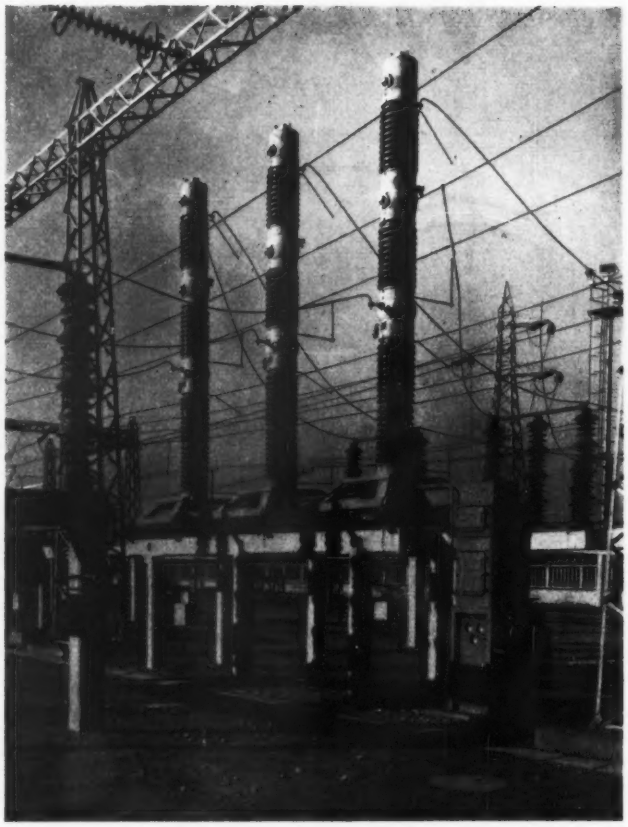

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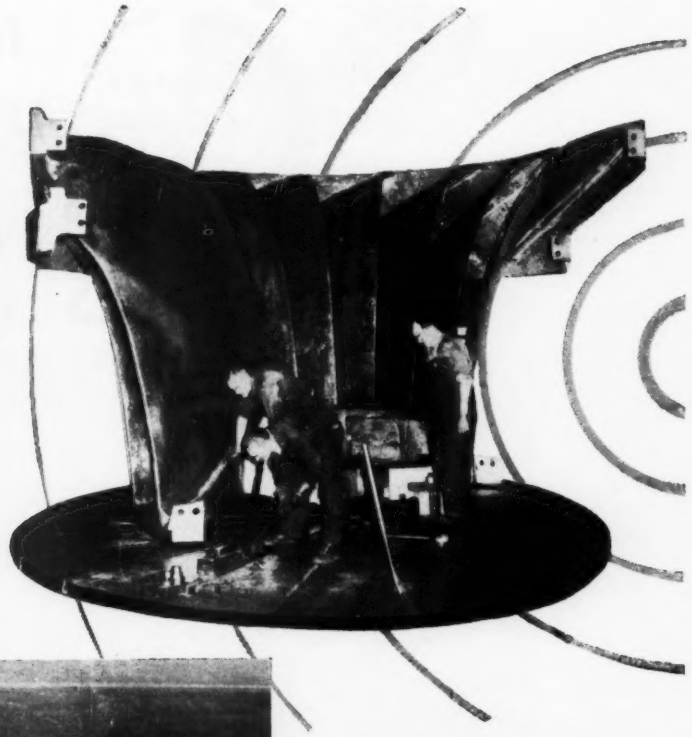

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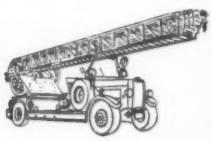

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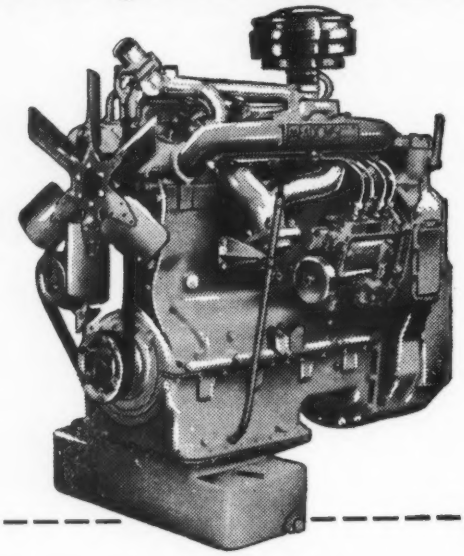

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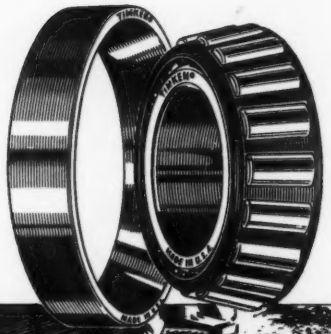

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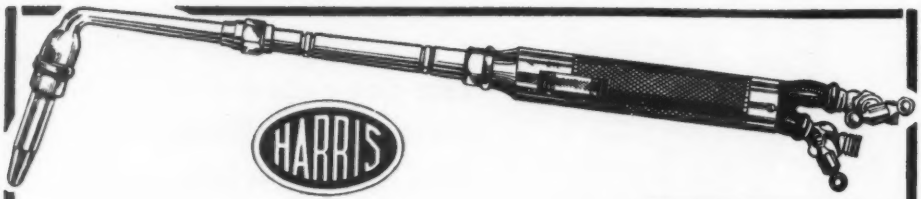

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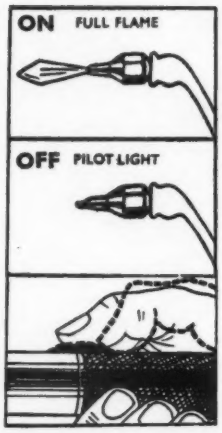

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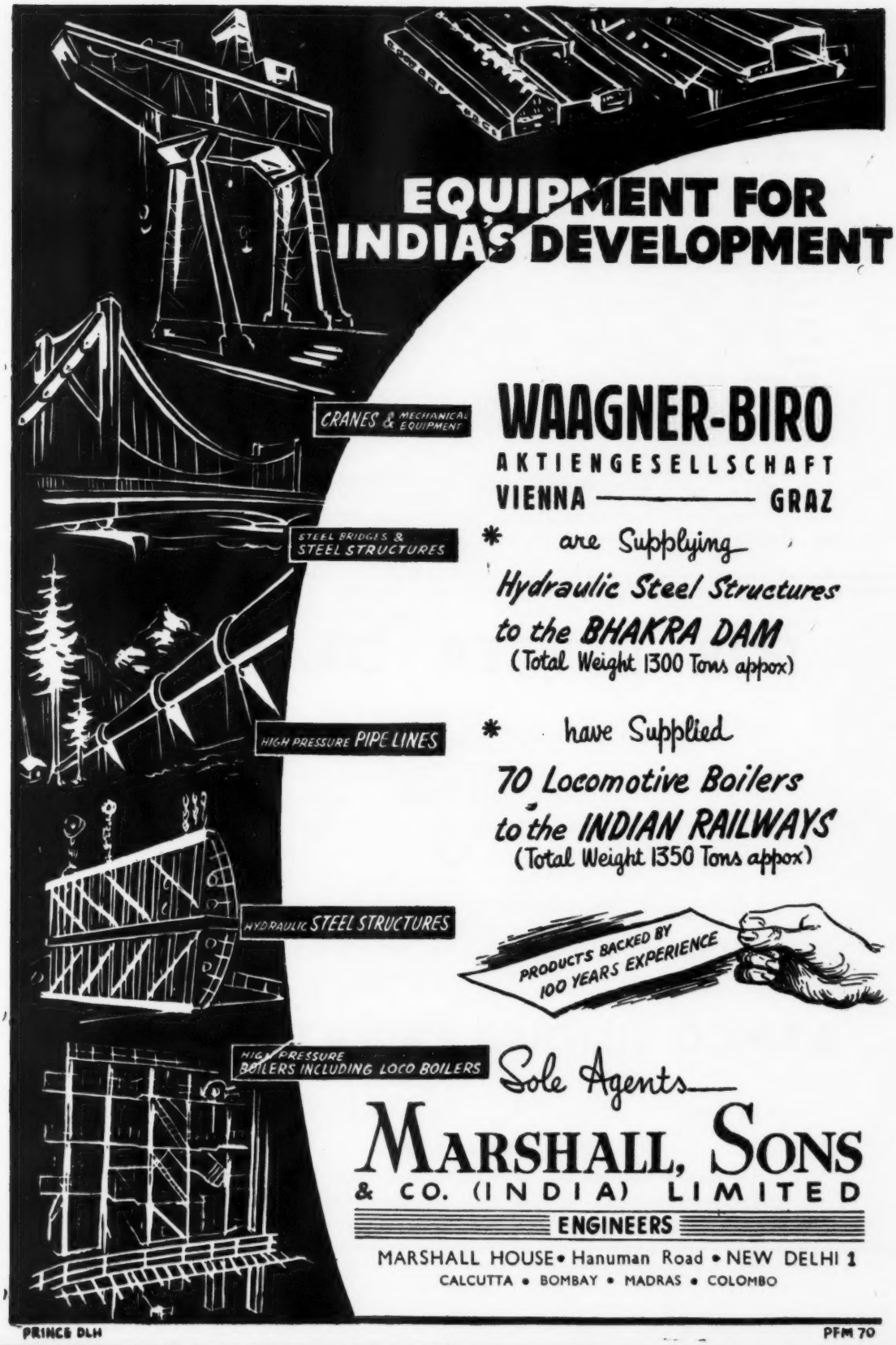
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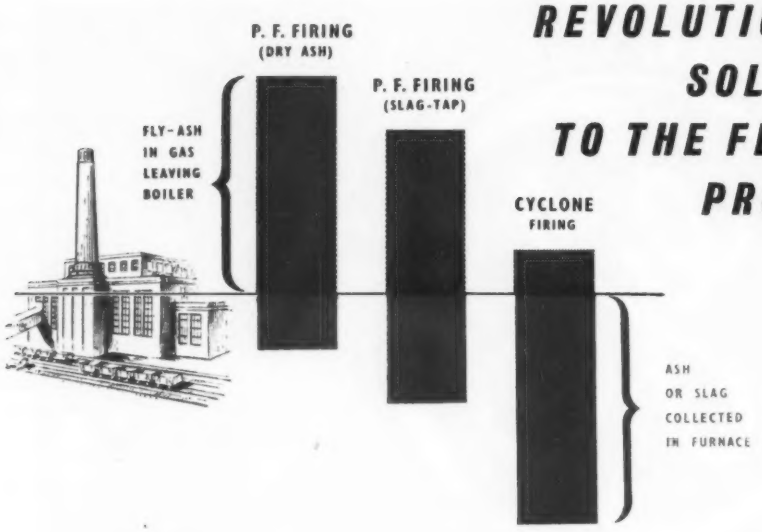

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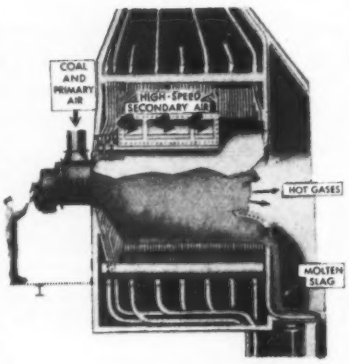

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Symposium on W. Bengal Rivers
(Sponsored by Engineers' Circle, Calcutta)

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The Engineers' Circle

The Engineers' Circle has been brought into being with a view to fostering a spirit of corporate life in our young engineers and broadening their general outlook by wholesome interchange of ideas with the patrons and other leading men of the profession on the one hand ; on the other hand, it may help to acquaint the experienced section of the profession with the hopes and aspirations, the thoughts and ideas that inspire the younger generation of engineers.

Besides, those who are charged with the work of co-ordinating the conclusions of pure science with the practical requirements of industrial developments, need to have frequent discussion amongst themselves, and to exchange their experience relating to allied scientific investigations. The Circle can offer an excellent forum and provide the much needed opportunities for such discussion amongst their fellow workers.

The Circle is in its infant stage, having been started in May 1954, and its resources are meagre. The idea of starting a symposium on the emergency situation arising out of the floods in this State of West Bengal was mooted soon after its formation. The importance of such a deliberation will be apparent. The Central Flood Control Board also decided to set up two River Commissions, one for the Ganga and the other for the Brahmaputra and its tributaries for controlling floods of these two rivers. It is also interesting to note that the Government is fully alive to the magnitude and the complexity of the problem and our Union Minister in charge of Planning, Irrigation and Power has rightly asserted that "the strength and resources of the nation has to be brought into play" to settle the comprehensive plan for flood control on an all-India basis and fix up priorities for this purpose.

This special number of the journal presents the series of lectures dealing with the various aspects of the rivers of West Bengal held under the auspices of the Engineers' Circle. We are sure, this will be of interest and hope that thoughts expressed therein will form the subject for joint constructive effort for the control and utilisation of the rivers of West Bengal.

It will be noticed from a perusal of this issue that the Circle considers it of great importance for engineers that they should have a wider general background of the understanding of the processes of nature in order to have a fuller grasp even in their specific field of study and work. It is in this spirit that the Circle has included a lecture by late Dr. S. L. Hora on the salinity of the Hooghly from the evidence of fish life.

On behalf of this Journal we extend our best wishes for a very active and intellectually vigorous life for the Engineers' Circle in Calcutta and to all such bodies in other parts of the country. We are strongly of the opinion that experience in actual work and constant exchange of such experiences, cumulatively resulting in improved knowledge, together lay the true foundations of an intelligent community and increasing prosperity.

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Rivers of West Bengal: An Introduction

West Bengal is full of rivers. This has obvious advantages as well as disadvantages. Now that this State is facing problems arising out of the influx of refugees and increasing population, it is but meet and proper that a fresh reappraisal of the river resources and the regime of the rivers is made and on that basis an integrated programme of phased development is drawn up. This contribution surveys the nature of the various groups of rivers in the West, in the North and in the South and studies their peculiar problems.

The rivers of West Bengal present certain features which can be traced to their origin. They can broadly be classified into three types with distinct characteristics. The rivers of the plateau area in West Bengal, for example, comprising the districts of Midnapore Bankura, Burdwan, Birbhum and western part of Murshidabad are as old as the terrain over which they are flowing. The rivers have taken their rise in the Ghatmahal of eastern Chota Nagpur adjoining West Bengal, and descend in slopes, which are rather gradual, debouching ultimately into the Bhagirathi-Hooghly or the Bay. The terrain is part of the peninsular shield of India and has remained a dry area since the early geological period. Cycles after cycles of pereplantation have gone by and the thalweg of the rivers give no indication of that. Recent rejuvenation of relief which are still to be traced in the Hazaribagh-Ranchi area in the form of rapids and waterfalls are met nowhere in the West Bengal plateau. The consequence is that the rivers in themselves have established their own load-volume-slope relationships and are fairly well designed by nature to perform their own task. But still floods are not infrequent in these areas. The reason is to be sought in imposed factors introduced by man.

The lands have been under the plough since time immemorial and little care has been taken of contour ploughing. Grazing is practically on a dangerous scale. Protecting covering is conspicuous by absence and plugging of gullies for arresting the spreading of bad lands are nowhere done. Sheet erosion at the time of precipitation and gully erosion immediately thereafter remove apalling quantities of top soil. This soil is ultimately carried to the channels where the soil and the water form a slur, so to say, and move down the slope. The volume and the slope are, now, no longer adequate to carry the load. Sedimentation in the bed of the stream is the inevitable result with shallowing stream sections.

The next important factor is the character of the precipitation itself. The average precipitation for West Bengal, as a whole, would be about 55 inches. If this were distributed uniformly or nearly uniformly throughout the rainy season, the rivers would be flowing evenly contributing to agriculture and sanitation. But the rain-bearing winds arrive in a series of storms, from the Bay, near the Hooghly mouth and head towards the Hazaribagh plateau. Two difficulties are created by this. First, as to direction and the second, as to the quantity. The rivers flow in a NW-SE direction. The rain-storm blow in a SE-NW direction almost diametrically opposite to the rivers. The mouth gets swollen first and the upper portion of the catchment subsequently. The flow of water at the mouth is slow, the channel section is flat and also narrowed down due to silting. The quantity precipitated at the upper catchment is greater due to relief and vegetation and the velocity of the water in the channels quicker. The inevitable consequence is that the water from the upper section of the catchment (Ghatmahals) overtake the flow in the lower section and spread beyond the banks. If afforestation is practised along the entire catchment, this in itself will go a long way in regulating run-off and preventing soil erosion. Together with contour-ploughing, crop-rotation and plugging of erosional gullies, the sheet erosion will be completely controlled. Forecasting with the help of Radar will enable excess flow to be held up in different segments of the valleys, thereby preventing excess flood. There is even the possibility of maintaining the channels free from abnormal silting and even scouring the clogged channels with the silt free water that would flow from the reservoirs.

The notoriety of two streams, in particular, the Damodar and the Kalighai is due to the disuse of the overflow system of irrigation with the march of time and the artificial embankment that have been thrown up to cater to vested interests alone. The problems for the Damodar will be solved almost completely if the D.V.C. succeeds in developing the valley on proper lines. So far as the Kalighai is concerned hydrological experiments and the field survey of the entire basin alone would give us the correct approach. The Kalighai has its special characteristic in that the central part of the basin is lower in level than the source and the mouth. Similar problem is encountered in the Barchouka basin, between the Haldi and the Rasulpur streams. It is a saucer shaped bowl.

The rivers in the Mahananda Brahmaputra doab are all Himalayan streams. Geologists have strong reasons to infer that not long ago, in the late tertiary period, a drainage existed from the Brahmaputra Valley in Assam towards the Indus Valley in the Punjab. The river has been mentioned as the Indo-Brahm. The long line of low hills facing the foot hills of the Himalayas, stretching from the Punjab to the Mahabharat Range in Bihar is known as the Siwalik hills. The sediments that have formed these hills are believed to

have been brought down and deposited by the Indo-Brahm. The Indo-Brahm hence also is known as the Siwalik river. At a subsequent period, possibly coinciding with the advent of the fossil man on earth, the mid-Siwalik valley was warped up, possibly near the site of the Delhi Ridge and the drainage split in two. The easterly drainage came to be established as the Ganges system. The Tista and the Brahmaputra were not then integrated with the Padma, as they now appear. Old hydrographic maps of Bengal, if reliable, show Tista as a mighty N-S stream more or less aligned along the railway route from Jalpaiguri to Paksi. The present volume of the Brahmaputra and its link up with the Tista are too recent to be credited with historic flavour. Desertion of channels, rather shifts in river valleys, are almost as frequent now, as they were in the past. In fact the rivers have not yet stabilised themselves.

A number of factors are to be sought out. The first one is that the rivers take their rise in the Himalayas, which are not yet worn down to a mature relief. The slopes are abrupt at the foot hills where the rivers have to negotiate a sudden drop. Prior to the foot hills the rivers have a steep valley, great volume of water and big chunks of load. The banks flatten out at the foot hills, volume is spread out in a large number of braided channels and the slope slackens. The debris are poured down and heaped up to form a cone. Neighbouring cones coalesce to build up fans, the rivers throw up bar plains. The channels are almost choked up by their own debris. The hydrological character demands that sufficient deposition should take place in the low areas and the Himalayas be sized down so that graded stream profiles be established. The attempt of man should be in helping this grade to be expedited, rather than in hindering it. This can be done by planned alluviation rather than by constricting river channels and accentuating high flood incidences.

Another factor that merits cognisance is the integrated character of the drainage pattern. If flood appears earlier in the Brahmaputra, it may hold up the disposal in the Tista where the storm may show later. If the Bay is stormy and hence the Meghna is in spate, the Brahmaputra, the Padma and the whole bunch of the North Bengal rivers would swell up. Thus the measures for flood relief should take stock of happenings in so many streams. Regulating the points of emergence at the plains will not help in relieving congestions from a long range view. Only, perhaps, the streams will be encouraged to desert channels at speedier rates.

The deltaic streams are the third category of streams in West Bengal. Their off-takes are in the Padma channel. The Padma is flowing through a levee and the off-takes are almost silted up. The pressure of the sweet water in the channels cannot keep down the increasing quota of the salt water that is pushed up from the Bay, due to the tides. Silt, which should normally reach down the river mouth helping in the extension of the delta towards the sea, is actually being thrown down in the beds of the streams. Off-takes are closed. Beds are silting down. No wonder that the streams are losing themselves in the maze of marshes. Local drainage cannot keep a channel hydrologically alive. Any attempt at controlling such streams that serve as tributaries to the deltaic rivers should be so planned as to enhance the quota of fresh water through them. Premature reclamation of delta-mouth, unco-ordinated urbanisation and unscientific lay-outs in roads and railways have already spelt disaster on the deltaic country. Further risks can hardly be accepted.

(*Continued from page* 5)

Hydrology of West Bengal Rivers

investigations in connection with River Control and Utilisation works. Much depends on the accuracy and extent of this survey. To devise flood protection works scientifically, to work out the details of an irrigation scheme economically and on sound principles, to design, construct and operate a multi-purpose river valley project, with confidence and profit, detailed hydrologic data of the river and its valley are essential. No efforts and money should be spared for their collection for as long a period as possible.

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Hydrology of West Bengal Rivers

By

Dr. N. K. BOSE, M.Sc., Ph.D., F.N.I.
Director, River Research Institute, West Bengal

AUTHOR

In this brief contribution the author succinctly analyses the functions of rivers and the causes of their failures and points out how it is of fundamental importance to collect extensive and reliable hydrological data of all the rivers in the State without which it is impossible either to control floods or to utilise these waters for generation of power or for irrigating lands.

Functions of Rivers—The rivers generally perform two primary functions that are of vital importance to human civilisation. These are drainage and land formation. When the river fails to perform either of these functions successfully, civilisation suffers. Floods are manifestations of such failures. When a river fails to carry the volume of water contributed by the drainage from the countryside through which it flows, it overflows its banks and floods the land. Other forms of failures are water-logging and formation of marshy boggy lands.

Causes of Failures—Why does a river fail to perform its normal functions? Why cannot a river always carry the drainage of the countryside, why do not deltas form at the mouth of all rivers ? The Ganga-Brahmaputra river system has one of the biggest delta of the world whereas the Indus has practically no delta. The reason for this difference is to be sought in the laws of river hydraulics. These laws are still imperfectly understood and most empirical.

Laws of River Hydraulics—The science of water movement is a fairly old science. Though its laws are not codified and expressed in mathematical terms, ancients had constructed canals and aquaducts to carry water from distant reservoirs and rivers to towns and centres of population. The canals that used to supply water to the temple of Martanda in Kashmir and the Roman aquaduct to the city of Rome are glorious examples of such achievements.

The empirical laws were however formulated later on. Most well known of them are those by Kutter, Chezy, Bazin and Mannings. Recently more work has been carried out by Lacey, Bose and others.

Collection of Hydrological Data—All these laws are empirical and depend for their success on the judicious selection of values for the constants involved in them. Particularly for rivers the constants vary from river to river. It has not been possible as yet to derive any universal laws of river hydraulics. Every river appears to be a law by itself ; yet they follow the general laws of hydraulics that govern all movements of water. The peculiar position is due to the fact that though in river hydraulics the general and universal laws of water movement are operative, yet these laws are influenced and in some cases considerably modified by the presence of detritus load that the rivers are made to carry. The nature of the country through which the rivers flow, the slope of the land, the kind of the soil and interaction with other streams also determine the final behaviour of the rivers.

It is therefore essential that hydrological informations for different rivers should be available for a considerable period before reliable empirical relationships can be derived for them.

What data to collect and how to collect them—The collection of these data is generally costly and difficult. The sites where these are to be observed are mostly in out-of-the-way places and the arrangements for their collection are elaborate and sometimes cost considerable amount of money. The quantities to be observed are usually (*i*) Velocity, (*ii*) Cross-section, (*iii*) Water levels, and (*iv*) Silt charge. In many cases temperature is also recorded. Water samples are analysed for *ph*, salt content and other chemical characteristics. Samples of bed materials are also taken with the help of a special type of sampler. Besides these, rainfall and other meteorological data are also collected.

Examination of the Data—These data so carefully collected are then examined in the laboratory by trained workers. Their analysis demand expert knowledge of statistics and a back-ground knowledge of hydraulics and river physics. A local knowledge of the sites of observation is also essential. Besides other detailed analysis the examination results in working out Rating Curves for the different sites of observations, a Unit Hydrograph for the whole catchment above the site, and total silt load carried by the stream.

Interpretation of the data and how to utilise them for designing various river training works—These are the basic data that are utilised by Design Engineers to fix the details of their dams, spillways and undersluices, the training and control works of barrages, the alignments and dimensions of flood embankments. The interpretation of these data for determining the life of a storage reservoir, for working out the operational procedure of dams and barrages, is an intricate process and demands skilled knowledge and experience.

Conclusions

Hydrologic survey is the pre-requisite for all

(*Continued on page* 4)

Salinity of West Bengal Rivers: Effects on Pisciculture

By

DR. SUNDER LAL HORA

Director, Zoological Survey of India

AUTHOR

The late author of this talk is welknown for his researches on Pisciculture. In this contribution he masterly surveys the problem of increasing salinitly of the waters of the rivers in South Bengal and discusses concrete schemes and proposals for taking timely action against the new danger to Calcutta which is the heart of W. Bengal. We hope the attention of all thinking men will be drawn towards the issues raised here.

Hydrologists have demarcated the estuary of a river into four zones, mainly based on its salinity regime. These are the Marine Zone, the Tidal Zone, the Gradient Zone and the Fresh-Water Zone. The Marine Zone consists of water masses which resemble in their hydrological properties the adjoining neretic waters of the sea. There is an almost complete absence of diurnal variation in chlorinity known as the "Chlorinity Conflict". The Tidal Zone extends from the upper limit of the Marine Zone to the lower limit of the Gradient Zone. Here the chlorinity conditions are stabilized at a high level and the "Chlorinity Conflict" is generally absent. The Gradient Zone represents the transition between the almost marine conditions in the Tidal Zone to the Fresh Water Zone. Within this zone the maximum variation in the environmental conditions occurs and diurnal oscillations brought about by tidal forces are characteristic of this zone. The "Chlorinity Conflict" is at its maximum here.

The demarcation of these zones is naturally very much dependent on the mechanism of flushing of the estuary in which the supply of head waters and the stability of the topographical conditions play an important role.

In all large estuaries, such as those of the river Ganga, the sea water being heavier, forms a wedge of brackish water at the bottom of the river while the lighter fresh water floats on the surface with decreasing thickness towards the sea. This enables certain bottom-living marine organisms to penetrate a considerable distance high up in such an estuary. The extent of this bottom wedge of brackish water is determined by the quantity of fresh water flowing in the river from above.

Another characteristic of a normal estuary is that it goes on building at its mouth and by depositing silt in its bed and on the adjoining low lands goes on receding from the land seaward. This is a comparatively slow process unless the natural regime of an estuary is interfered with.

Characteristics of West Bengal Estuaries

In dealing with the rivers of West Bengal, one has also to bear in mind that there is a gradual shifting of the rivers from the west to the east which is contrary to what happens with the Himalayan rivers where a general shift is known to have taken place from the east to the west.

The rivers of West Bengal, besides the natural causes affecting them, have been greatly interfered with since the establishment and growth of the city of Calcutta on the River Hooghly. Human interference is in fact a major factor in the deterioration of a number of estuarine rivers of Western Bengal. I shall, however, confine my attention to the effects of these combined forces on the salinity regime of these rivers as revealed by the distribution of fishes in earlier periods and compare the same with the conditions prevailing to day and equate the results against pisciculture practices. As far as my knowledge goes, no intensive work has so far been done to enable a proper demarcation of the precise limits of different zones in any estuary of West Bengal. However, certain uncorrelated biological data are available to judge the variations in the salinity of West Bengal rivers.

Salinity Tolerance by Organisms

It may be mentioned here that as a general rule marine organisms cannot live in fresh waters and *vice versa*, though there are anadromous animals, like Salmon and catadromous animals, like Eel, that live part of their lives in fresh water and part in the sea. The estuarine animals exhibit a certain range of tolerance to fluctuations in salinity as an adaptation to their varying environment and in fact it is generally believed that estuaries have provided a high way for the migration and gradual acclimatization from marine to terrestrial or fresh water conditions. Majority of animals or certain animal and plant associations can serve as a valuable index for changes in salinity. Intensive investigations on the fauna and flora of rivers have been conducted in western countries and through these biological surveys it has been established that the main features of the hydrology of the river can be figured out with a fair degree of accuracy.

The Adi Ganga

In 1798, Fancis Buchaman (afterwards Hamilton) was stationed at Baruipur and he made a study of fishes found there. Descriptions of the fishes obtained by him then are to be found in a manuscript

volume kindly presented by Dr. G. P. Whitley of the Australian Museum, Sydney, to the Asiatic Society Calcutta.[1]

A perusal of this most valuable document shows that Baruipur was then situated on brackish-water channel and that the marshes round about it were then flooded with saline waters. That channel known as Adi Ganga, is no more, now being represented by a series of ponds and tanks, and the fish fauna of Baruipur at present comprises of purely fresh water species. There is no record of pisciculture at Baruipur in 1798, but if fish culture was undertaken then it would have been of Bhetki, Parsia, Bhangan, Bagda Chingri and similar other varieties of brackish water fishes. Now only Pona (Carp) fish are cultured in the ponds and there is no brackish water fishery in the neighbourhood of Baruipur. I do not know whether the death of the Adi Ganga was due to natural causes, such as silting of its bed and shifting of its channel from west to east, or through human agencies, but the fact remains that profound changes have taken place since 1798 in the regime of that river

The Hooghly

The Hooghly in its upper portion has behaved according to natural laws because the main stream of the Ganga having shifted eastwards has deprived it of its head-waters and the consequent silting of its bed has made the situation worse. During a greater part of the year there is hardly any supply of fresh water for flushing its bed. If there were no large towns on its bank which are protected through high embankments it is probable that this river may have had the same fate as the Adi Ganga referred to above. Owing to the necessity of maintaining Calcutta as a large port accessible to big ships, the lower portion of the river is kept deep by dredging; so a constant fight against natural processes is being valiantly put up by the Port Commissioners. Any neglect in this fight may lead to the decline of the importance of Calcutta. With the increase in the sizes of ships coming up to Calcutta, naturally a wider and deeper channel is necessary for their movements. I have no information on the dredging activities of the Calcutta Port Commissioners but observations made on the fishes of the Hooghly river since 1937 show that my presumption must be correct. A wider and deeper channel from the mouth of the river would result in the extension inland of the Marine, Tidal and Gradient Zones and pushing back of the Freshwater Zone. In a series of articles (Hora 1943, 1953, 1953a, 1955) I have shown how the distribution of fishes in the river Hooghly provides abundant evidence of the rising salinity of the river. Here also the brilliant researches of Francis Hamilton, the writer of Gangetic Fishes in 1822 and father of Indian Ichthyology, on the fishes of the Hooghly while stationed at the Royal Botanical Garden upto 1814 provide the historic background for our present purpose. In 1937 I carried out a fish survey of the Hooghly above the Calcutta Water Works and found certain marine and esturaine fishes from the bottom of the river. During the last three/four years greater interest has been taken in the training of this river and a look into its fish fauna has shown that upto Namkhana Canal certain purely marine pelagic fishes have been captured in commercial quantities showing very clearly the penetration of the Marine Zone. The Zoological Survey of India party working in the upper portion of the river has found evidence of the extension of the Gradient Zone. If such changes are accelerated by more and more dredging without flushing the river from the top it is probable that the Pulta Water Works will one day become a Brackishwater Fish Farm and the city's water supply will have to be arranged from other sources.

The Bidyadhari

The Salt Lake of Calcutta was a brackish water lake not very long ago though it is now partitioned off into a number of freshwater *bheries* for the culture of pona (Carp) fish. This lake formed the spill area of the Bidyadhari River when that river was alive and active. In the normal course this river would have filled up the Salt Lake and provided us with valuable land for the expansion of Calcutta, but the Calcutta Corporation scheme of utilizing it as an outfall channel for the sewage disposal of Calcutta hastened its end. The construction of the Dhapa Lock and the premature reclamation of adjoining lands by throwing embankments on both banks of the river interfered with the tidal flow of the river and sewage reacting with salt water became precipitated at its bed like layers of cement after cement. This process ultimately choked the river by raising its bed prematurely, stopping its spilling in the Salt Lake area and also stopping it from carrying the sewage of Calcutta. It was thus through our shortsightedness that the reclamation of the Salt Lake area has become such an expensive and necessary problem. I shall revert to this subject later for I must deal with pisciculture first for which I have clear records. For instance, Sri K. G. Gupta in his "Reports on the Results of Enquiry into the Fisheries of Bengal and into Fishery Matters" (Calcutta: 1908), has referred to pisciculture in the Salt Lake area in paragraph 110 on page 34 and again among his recommendations in paragraph 122 on page 86. Even at the risk of giving a long quotation, I would like to repeat here what Sri K. G. Gupta said in 1908, for his recommendations are so sound that Bengal's fisheries would have prospered had they been adopted. This is what his advice was with regard to Bheries :—

> "Another way of increasing the supply of estuarine fish lies in the direction of improving and extending the system of Bheries which is found so profitable in the Salt Lake in the neighbourhood of Calcutta. These Bheries are not unlike English mulletries and serve as temporary nurseries. They are within easy distance of Calcutta and can be inspected by any one interested in the business. A large portion of the Salt Lake has been made up into shallow reservoirs by means of low embankments, arranged on the sides of a canal from which the ponds are fed during flood tide through sluices, the valves of which open only inwards. Fry and young fish are thus admitted but their escape is prevented when water is let out. Prawns, Bhetkis and other fish are thus imprisoned about June and July and are caught from time to time and sold from July till the following January or February when the ponds dry up. Bhetki is largely caught in this way, but it is usually of small size, seldom exceeding 1/2 seer, and is poor in flavour. The small bhetkies that are

[1] Unfortunately this MS volume was badly damaged at Banaras in '43 owing to flood in the Varuna river. I published a description of this MS in the Journal of the Society (Journ. Proc. Asiatic Soc. Bengal (N.S.) 27,123-135, 1931).

seen in the Calcutta markets in September, October and November are often the product of Bheries. The fishermen came from various places, and there is keen competition among them owing to which the rents are going up so much that the owners of the lands find it more profitable to convert their low paddy fields into Bheries. It is not uncommon to see Rs. 15/- paid per bigha for a year, but the fishermen who are not very rich complain bitterly of this rack renting. The leases are generally annual, though the term is in some cases extended to three years. Owing to the short term system and to the poverty of the fishermen, the Bheries, are emptied and all fish taken out by end of January. But if longer terms were given and capital were available, the embankments could be made stronger and higher and the Bheries made into regular rearing ponds in which the fish could be made to grow to a proper size before being caught for the market. Artificial feeding would improve the rate of growth. The present system is shortsighted and destructive to a degree.

"It is almost certain that a system which has been so profitable in the Salt Lake would be equally successful in other areas where the conditions are not dissimilar. There must be many low lying lands in the Sunderban where Bheries can be introduced with success. The main difficulty is the absence of quick means of carriage, but the employment of gasolene boats would obviate this difficulty, and fishermen could get land at no great distance at a much lower rate of rent than what has to be paid in the Salt Lake.

"The system of Bheries is capable of indefinite expansion, and some of the capitalists who are now engaged in reclaiming the Sunderbans for growing rice may find it more profitable to take to fish culture, for which few acres would suffice and which would call for no great outlay. This work could also be carried on alongside of the cultivation of rice.

"The fishery department might take up the question of improving and extending the Bheri system and start experimental station for the purpose."

The Department of Fisheries that was set up on the recommendation of Sri K. G. Gupta did pay attention to Carp culture and Hilsa fisheries but I do not think much attention was paid to Salt Water Bheries. However, the working of Salt Lake Bheries proved so attractive that capitalists did put up Bheries in the Sundarbans and employed gasolene boats for carriage of fish round about 1929. For the 2 or 3 years, each Bheri proved very successful but later with the increase in salinity inside the Bheri, crabs and certain boring fishes made tunnels in the embankments to escape from increasing salinity and thus ruined the Bheri, causing heavy losses to the owners. There was no fishery department then to suggest improvements in the Bheri system. However, when a department was established again in 1942, I found a number of deserted bheries in the Sundarbans and some new ones started. Some working on year to year basis were also found intact as there could not be any question of rise of salinity in such Bheries, being dried up annually. Mr. (now Dr.) K. K. Nair and I started investigations at Sisirganj and made suggestions for improvement of such Bheries in Pamplet No. 1 of the Bengal Fisheries Directorate in 1944. When a bheri had a fresh water supply to keep down rise in salinity, fish could be reared and fattened over a number of years while in others annual total cropping seemed to be fully justified. Thus salinity had a marked effect on pisciculture so far as the working of such Bheries is concerned.

Having investigated and understood the scientific principles of the working of such Bheries, the next step was to extend this system as there was great demand for estuarine fish from the English and American forces during the war. The law of Permanent Settlement came in the way and the District Magistrate of 24 Parganas would not allow suitable areas to be used for pisciculture for they had been given to be reclaimed for paddy cultivation. It has not yet been realized that salt water Bheries in the low lying areas of the Sundarbans can actually be a stage in the reclamation of those areas for paddy cultivation afterwards. The area is first embanked and a branching system of canals is constructed to enable regulated inundation and draining of the area; during the high tides water is taken into the embanked area and it is prevented from flowing out by beams of sluice gates. The silt brought in by the tides is deposited in the embanked area and gradually the level of the ground is raised. When it is raised to the required level—this would take several years to complete—the taking in of tidal water is stopped and during the rainy season the area is flushed with rain water to wash out the saline contents of the soil. When this is repeated twice or thrice, the land would have become suitable for cultivation.

However, some existing Bheries were improved and one of them on the Bidyadhari has been under observations upto about a couple of years ago. This Bheri is near Gutyari Sharif and will be briefly described now. During the period of my Directorship of Fisheries, Bengal (1942-47) this *bhasa-badha* fishery was working very satisfactorily as it had extensive paddy fields in the neighbourhood from which fresh water drained into the fishery. A student of mine worked on the ecology and mullet culture practices in the fishery during 1950-52 and has found that supply of water has become a great problem in the Bheries situated in the area. The rapid silting of the river system has resulted in very marked reduction in the tidal ranges. So much so, the Bheries hardly receive water supply for more than 3 or 4 days round about the full moon and new moon periods. Because of this it has become impossible for the fish culturists to inundate the whole of the embanked areas. The major part of the Bheries now remain dry during the dry months and it is only during the rainy season that there is a sufficient depth of water in them. This has naturally resulted in restricting the productivity of these fisheries. However, it has been observed that in a place only a couple of miles from Ghutyari Sharif where a tributary of the river has been formed and where a tidal range of about 12 ft. has been produced, there are now a number of very productive Bheries receiving very adequate supplies of water. This clearly shows that silting up of the river is adversely affecting fish culture in Bheries. If these Bheries are to be properly worked either means would have to be found for making available a good supply of brackish water by improvement of the rivers or suitable supplies of fresh water will have to be found to supplement the

limited quantities of brackish water that can be obtained from the river. If large quantities of fresh water are thus fed into the Bheries the salinity of the Bheries will be greatly reduced and the story of the Salt Lake of Calcutta will be repeated in the lower part of the Bidhyadhari River system.

Reclamation of Salt Lake

When we are still considering the changes in the regime of the Bidyadhari River, I may be permitted to say a few words about the proposals for reclaiming the Salt Lake area for the extension of Calcutta. The Calcutta Improvement Trust had put up a scheme of filling up the area at a cost of Rs. 13·5 crores (if I remember the figure correctly) but after a careful study and layout of the existing sewage irrigated fisheries in the area I gave a scheme for 1.5 crores of rupees by which pisciculture could be standardised and made more productive through excavations of certain areas, canalisation to feed fisheries and reclamation of vast areas for the extension of Calcutta. Though the then Governor, Mr. Casey, liked the scheme, it met with great official opposition and now lies burried in the files of the Directorate of Fisheries. The interest in the utilization of this area has now revived and some Dutch experts have been invited to advise West Bengal Government in this matter. May I suggest that the scheme that I submitted then may also be examined because the return through pisciculture of the entire outlay and good profits are guaranteed in it.

Fertiliser from Bidyadhari Bed

As the deterioration of the Bidyadhari was hastened by the sewage disposal into it, large quantities of digested sewage ready to be utilized as manure are now lying in the dry bed of the river. In some places people are taking it out and using it as fuel like cow dung. I think an enquiry into this manure resource is needed.

The Piali

The deterioration of the Bidyadhari as an outfall channel for the disposal of Calcutta sewage was so rapid that before the transference of sewage disposal to the Kulti some make-shift arrangement had to be made. The Piali River was chosen for the prupose and it began to deteriorate very rapidly. I investigated the fauna of the Piali at Uttarbhag in 1930-31 and found it to be typically estuarine but a couple of years later the sewage had changed its ecology considerably and now the conditions are very different there. Only fresh water fish culture is possible in the area.

The Matla

In a series of articles (1907-1909) Annandale recorded the estuarine fauna of Matla at Port Canning and in 1921-22 I had also an opportunity to study this fauna and found it to be more or less similar to what Annandale had described, but during 1942-46, I found vast changes had taken place. There are large number of Bheries based on tides in the Matla and with the deterioration of this river they are also deteriorating. The death of Bidyadhari and the Piali hastened the deterioration of the Matla.

The Kulti

Now it is the turn of the Kulti River to deteriorate under the impact of the Calcutta sewage and I have investigated personally the changes that are taking place in the fishery of the river. When the sluices of the outfall channel are opened, a considerable part of the river becomes septic and large quantities of fish die. Though the sewage through sedimentation, is blocking up the channel specially constructed to take it to the Kulti, such amount as is going into the river will settle at its bottom. The problem of this river is for the present that of pollution and its effect on fishery and not on fluctuation in its salinity regime.

Suggestions and Recommendations

I have referred above to certain rivers of West Bengal for which some fish and fishery data are either available in literature or I have personally carried out some observations on them. The changes that we have noted above are of two types ; those that are inherent in all deltaic rivers and are brought about by natural causes and secondly those that have resulted from human interference with the natural regime of the rivers. We have numerous estuarine creeks in West Bengal and most of them are behaving in accordance with natural laws and we, as a rule, do not take notice of them. There are other estuarine rivers which we have pressed into our service by altering or interfering with their normal behaviour. Unfortunately in all such cases, we thought of our immediate needs and requirements and acted without considering the ultimate fate of these rivers and of our schemes based on their normal behaviour. In the case of the Hooghly, I have already suggested that salinity recording stations at suitable places in the lower and middle reaches of the estuary be set up so that the threatened danger to the town of Calcutta can be sighted well in time to be averted. Improvement of head water supply by the construction of the Ganga Barrage seeems to be the most suitable means of arresting the further deterioration of the river. The study of seasonal faunal distribution in the river at various depths may prove to be an efficient means of assessing trends of salinity changes in the river

As indicated above, the legacy of the Bidyadhari river at the Salt Lake area and the sewage manure in its bed. For the former, I wish to enter a plea that my fishery scheme in connection with the reclamation of Salt Lake may be examined for it will not only be a a profitable project but will help to save the Kulti outfall scheme by prolonging its life. If the sewage water after sedimentation, can be used for irrigating Salt Lake fisheries, the outfall canal and Kulti River will continue to serve Calcutta well for a long time to come. Moreover, a large supply of Pona fish will become available from Bheries near Calcutta.

Long time ago, there used to be an Advisory Board of the Calcutta Corporation for its water works at Pulta and I believe that it did useful work. This Advisory Board cost the Corporation practically nothing for scientists in this country have not yet become money conscious for the advice they may give. Here in Calcutta, we have the most advanced research University. Calcutta is also the headquarters of many central scientific organisations. We have the resources of the Commissioners for the Port of Calcutta, the resources of the Calcutta Corporation and lastly of the Government of West Bengal. There is thus no dearth of talents in the city to tackle the problems presented by the rivers of West Bengal on a long-term basis. Some one with a vision is needed to harness this talent in the city. For this

(*Continued on page* 20)

Inland Water Transport: West Bengal

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This contribution deals with a most neglected, though important, aspect of transport in W. Bengal. In the past rivers were the most important form of transport and communication. But with the development of railways, it fell into disuse. Now when the pressure of transport is growing with years, it of is utmost urgency to develop water transport side by side with other forms. The author surveys the present situation and problems and also deals with another chronic problem of W. Bengal, namely, that of the Port of Calcutta.

When it is remembered that the Port of Calcutta handles 50 per cent of the country's sea borne trade, the influence of the waterways on the prosperity and economy of this State need hardly be emphasized. Although most countries in the world have all developed their inland waterways and are utilising them to the maximum extent, it is doubtful if there is any other area, where the system of internal river communication has been so well planned by nature, as in north-east India whose river system is unique in this respect. The partition of India, has resulted in the deep and valuable inland waterways of East Bengal becoming part of Pakistan

We are all aware, that prior to the advent of railways, inland water transport was the only means of communication between Bengal and the north and the north-east India and by about 1850 regular fortnightly steamer services grew up between Calcutta and Agra. With the development of railways and the indiscriminate construction of marginal embankments to protect the railway and other interests to the detriment of the rivers, inland water transport did not receive the proper attention it merited. Mostly due to the vagaries of nature and partly due to human interference the three Nadia rivers, the vital means of water transport of this State, have gradually deteriorated. With the deterioration of the Bhagirathi, the most important of the three Nadia rivers, the Jalangi and the Matabhanga (now forming the boundary) were utilised but with the deterioration of these rivers, attention was paid to developing the navigation route through the Sunderbans. Thus except for two months in the year in the rainy season when the Bhagirathi is navigable, inland vessels bound for Bihar have to make circuitous detour through the Sunderban route (most of which falls in East Pakistan) involving an additional distance of 450 miles.

I now invite your attention to the map of river system of north-east India showing the waterways of West Bengal.

The Hooghly

Let us now consider the waterways of the State. As I have stated earlier, when we talk of the rivers of Bengal, our thoughts turn to the river Hooghly, with the Port of Calcutta, which handles over 50 per cent of the country's sea borne trade. The upper Hooghly between Calcutta and Nabadwip (confluence of Bhagirathi and Bhairab-Jalangi) is navigable throughout the year, although the available depths above Tribeni are limited during the dry season.

Western Tributaries of the Hooghly

We next come to the western tributaries of the Hooghly. Of these only the Rupnarain is navigable. The history of these rivers is one of progressive decay and they are lost to us for inland water transport except for shallow draft country craft in their tidal reaches. Even in the case of the Rupnarain, we are feeling the ill effects of restricted spill area due to premature reclamation by marginal embankments. This river is navigable all the year round upto about 12 miles. Above Kola Ghat, the river is shallow and during the dry season launches drawing 1½ feet of water only can navigate upto Gopigunj.

Rivers to the east of the Hooghly

We have the river system eastward of the Hooghly comprising of the Jamuna, Bidyadhari and Matla (refer to map.)

The Matla was on several occasions during the last century, considered seriously as an alternative, when fears as to the future of the Hooghly were expressed. The deterioration of the Bidyadhari commenced with the premature reclamation of land on either bank of the river in the middle of last century and has ultimately ended in this river presenting a serious problem to the city of Calcutta. The Matla is also deteriorating owing to restriction of spill area although development of inland water transport of shallow draft craft is still possible.

The Jamuna river (known as Ichamati) which forms part of the inner boat route, flows through a thickly populated and fertile district. I believe it is navigable as far as Badoria for larger inland vessels and further up as far as Gobardanga for light draft vessels. The prospects of traffic for inland water transport are good.

North Bengal Rivers

Of the North Bengal rivers, which are non-tidal, there is insufficient data. There does not appear to be any scope for inland water transport. With the Ganga, Kosi and Teesta schemes, there may be a possibility of navigable canal through this region connecting Bengal and Assam.

The Canal System

Let us now consider the canal systems. The two

principal canal systems are (*a*) Chitpur and Circular Navigation Canals and (*b*) Orissa Coast Canal.

(*a*) The Chitpur and Circular Navigation Canals are important because they connect the Calcutta Port with the waterways system of East Pakistan through a number of narrow waterways which could be navigated by country boats during all seasons so that the exposed and dangerous outer route could be avoided. Self-propelled craft could be introduced in the area to improve the turn-round of country craft, although speed restrictions have to be imposed. Construction of these canals including the Chitpur lock was taken up early in the nineteenth century and improvements were maintained and Kistopur canal was constructed about 1910.

The Orissa Coast Canal

(*b*) The Orissa Coast Canal was opened in 1880 to serve as a navigation connection between Bengal and Orissa. The canal commences at Geonkhali, at the confluence of the Rupnarain and the Hooghly and is known as Hijli Canal upto the Rasulpur river from whereon it is known as the Orissa Coast Canal and connects through Kendrapara Canal system to the Dhamra and the Mahanadi systems. It is 120 miles in length and was originally intended to carry 7 feet of water. With the advent of railways, the canal lost its importance, and this waterway has been sadly neglected and canal navigation between Balasore and Burahblang is at present a closed chapter. It is believed that what once used to be a canal now alternates with cultivation and fish ponds. The tail end of the canal is, however, maintained by the Orissa Government between Subarnarekha river and the State boundary while the best stretch of the canal lies in West Bengal where depths of 4 to 5 feet are available at high tide. It is a great tragedy that this canal has been allowed to deteriorate. Although admittedly with the development of railways it had lost its importance, with the developments now taking place in the Mahanadi area and the vast potential resources being developed in Orissa whereby the Government envisaged huge exports of iron ores of the order of two million tons per year and the prospects of developing new port on the Mahanadi, this canal would provide a vital link to the port of Calcutta. The proposal of the West Bengal Government to manufacture salt at Contai, if it materialises, would emphasize the necessity of resuscitating and maintaining it. A close survey should immediately be made to assess the capital and recurring expenditure required to resuscitate this canal. The traffic potentialities of the hinterland are enormous and indications are that the canal would be a paying proposition to both the State Governments concerned. With the nationalisation of railways and other transport, coordination and not competition is the order of the day.

Admittedly, there are certain practical difficulties such as the canal interfering with the local drainage of the countryside and runoff of the flood waters of several rivers. But these difficulties are not unsurmountable and can be tackled as was done in the Upper Ganga Canal taking off from the Ganga at Hardwar, which has been provided with several aqueducts for the rivers and drainage channels crossing it and this was done almost hundred years back.

D. V. C. Canal

The D. V. C. authorities are constructing an irrigation cum navigation canal along the left bank of the Damodar, connecting the area at Durgapur downstream of Ranigunj Collieries with the Hooghly about 35 miles upstream of Calcutta. The canal is 85 miles long and has 24 locks. The width of the canal is 120 feet while the locks are 20 feet wide ; the depth catered for being 9 feet. While unfortunately the canal cannot connect the port of Calcutta right upto Ranigunj collieries, it will nevertheless provide a very useful waterways between Durgapur and Calcutta Port.

The Sunderbans are intersected by numerous streams, and large rivers. Inland water transport is the only means of communication in this area. Here nature has helped us in providing navigable cross channels connecting the estuaries of the rivers running from north to south. Here again, marginal embankments constructed prematurely to prevent the tidal water from spilling over areas developed for cultivation have resulted in the deterioration of some of the channels. If, therefore, the existing channels are to be maintained in healthy state, both as vital means of water transport and as means of providing drainage and sanitation to large area, the following measures should be adopted.

(1) Prevention of construction of marginal embankments along the edge of the river till the area is reclaimed above normal high tide by nature.

(2) Scientific dredging for improving and maintaining the existing channels.

Let us now consider the existing rail and river traffic so as to be able to assess the potentialities of Inland Water Iransport of this State.

Total Rail and River borne Traffic between West Bengal, Bihar, Uttar Pradesh and Calcutta Port

Year	*Rail borne Traffic*	*River borne Traffic*	*Total*
1946-47	25,32,28,716 Mds.	1,52,59,276 Mds.	26,84,87,992 Mds.
1947-48	21,19,72,212 ,,	1,42,61,530 ,,	22,62,33,742 ,,
1948-49	27,84,88,601 ,,	3,33,833 ,	27,88,22,434 ,,
1949-50	42,11,29,913 ,,	2,82,042 ,,	42,14,11,955 ,,

The above statement indicates the rail and river borne traffic between different trade blocks for the years 1946-47 to 1949-50. Although I have not been able to bring the figures up to date, there has been considerable improvement in the traffic handled especially on the waterways since 1950. It will be seen that there has been an overall increase of traffic after independence although huge decline in river traffic was due to disturbances and the insecurity in East Bengal through which all traffic coming from U.P. and Bihar to Calcutta had to pass. It can be safely assumed that, with the developments taking place all round us there is bound to be further increase in traffic a good percentage of which can be economically handled by the Inland Water Transport when the new Farrakka-Jangipur canal as a result of the Ganga Barrage comes into operation shortening the route and confining it to the India Union entirely.

The Government of India have recently formed the *Ganga Brahmaputra Transport Board*, with the States of Assam, Bengal, Bihar and Uttar Pradesh as members. The Board is preparing to stage a pilot project to demonstrate that with more modern shallow draft tugs to suit local channel conditions and with improved method of towage, it will be possible to develop Inland Water Transport to operate more economically than at present, notwithstanding the fact that the distance by river such as the Ganga, due to its meanders is considerably greater than the distance by rail or road. This project should be watched with great interest by all concerned, especially, the private operators and the State Government, who by benifitting from the lessons of this project can play a vital part in improving the existing water transport facilities in the region.

I shall now discuss the navigational problems of river Hooghly and the Port of Calcutta.

Navigational Problems of the Hooghly River

The Hooghly, from its early history, has been a problem river. It is, therefore, not surprising that proposals had been made from time to time starting from about 1795, firstly to shift the port below Diamond Harbour, subsequently to develop Port Canning on the Matla as the port avoiding Calcutta and the Hooghly altogether, and recently to construct a ship canal from the head of the dock system to Diamond Harbour to short circuit the 42 mile stretch of the river Hooghly and to provide a deep water approach to the dock system in Calcutta.

All these proposals were ultimately not found to be long term solutions to the problems they were designed to solve and Calcutta, inspite of its limitations as river port, occupies a unique position among the major ports in the East.

The port handles annually in the region of 9 million tons of cargo. The Commissioners maintain two dock systems namely the Kidderpore and the King George docks, in addition to river moorings and the river-side berths at Garden Reach and Calcutta jetties and special petroleum wharves at Budge Budge. The number of sea-going vessels visiting the port is about 1,200 to 1,800 per year. Over 100 vessels can be berthed in the port on any single day.

The sea-ward approaches to the port from Sandheads about 130 miles from Calcutta are difficult to navigate and pilotage is compulsory. There are several bars and crossings in the Hooghly above Diamond Harbour and three principal bars in the estuary.

I now invite your attention to the plan of the river Hooghly, where the bars and crossings from the sea-ward approaches to Calcutta are indicated.

The estuary fans out below Diamond Harbour assuming a regular funnel shape and is 13 miles wide at Saugor. The Channels and sands below Saugor referred to as "Sandheads", all run towards what is known as the "Swatch of no Ground" at the head of the Bay in a SSE direction. A redeeming feature of the Hooghly estuary is the fortunate absence of 'littoral drift'—a coastal drift of sand, which has been the problems of port on the east coast of India.

Balari Bar is the weaklink in the chain of bars below Diamond Harbour where, as the Hooghly ebb emerges from the constriction at Kantabaria, the lines of flow are widely dispersed and Balari Bar, which is a channel maintained by the tidal inflow, draws the bed material and silts up especially in the freshets. Balari Bar has been navigated without break since 1872 and model experiments are in progress to develop this channel.

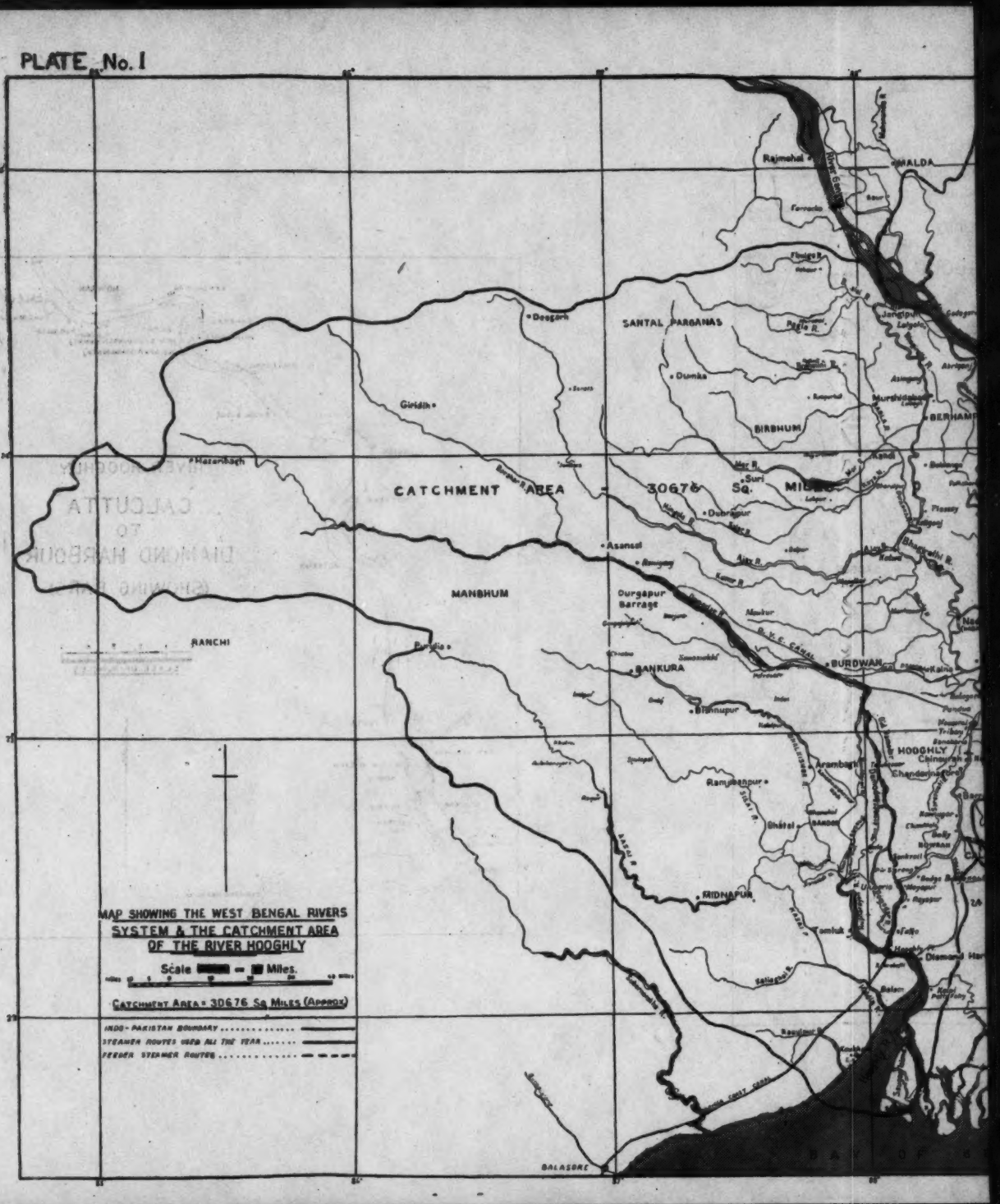
Above Diamond Harbour, the section of the river in the vicinity of confluence of the Rupnarain and the Damodar with the Hooghly, is complicated and is weakest link in the chain. Owing to the river taking a right angle bend off the confluence of the Rupnarain, the tidal inflow sweeps past the right bank of the river along the Western Gut Bar, leaving a strong ebb eddy running down the channel along the left bank of the river known as the Eastern Gut Bar. These flow conditions have been responsible for the area notoriously known as 'James and Mary Sand" being the graveyard of many sailing ships and low powered ships in the early days of steam. The Eastern Gut Bar, which deepens with the advent of the freshets, has to be maintained by intensive dredging for about 8 months in the year as the bar shols considerably in the dry season to the maximum extent of 4 to 5 feet a day.

Ninan Bar forms in the double concave below the confluence of the Damodar and shoals in the freshets when, owing to the protrusion of Fulta Point, the Hooghly ebb dissipates to the westward, the Damodar discharge being too feeble to deflect the Hooghly ebb on the left bank. The stronger the Hooghly freshet, the worse Ninan becomes. This bar, which has been giving considerable trouble in recent years necessitates considerable amount of dredging to maintain the hydraulic balance between the Hooghly and the Damodar but improves during the dry season.

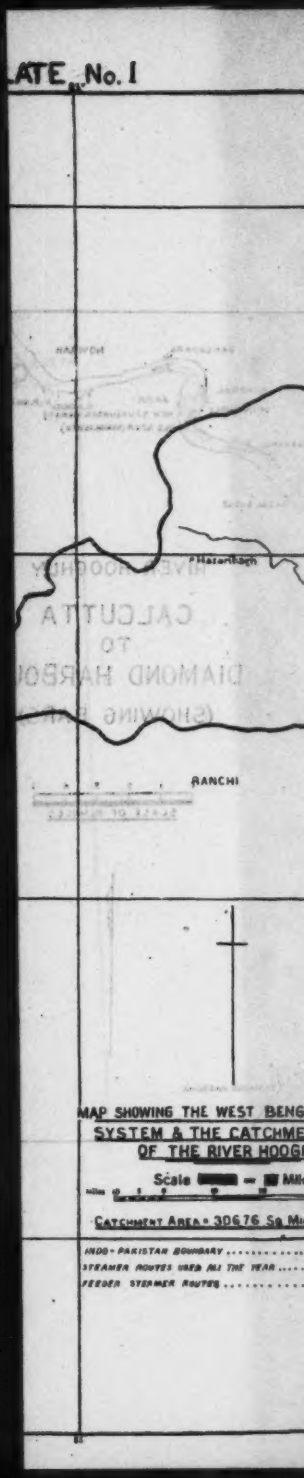
Fulta Reach upstream of the Damodar outfall also gives trouble as the tidal inflow pushes the Fulta sand into the channel.

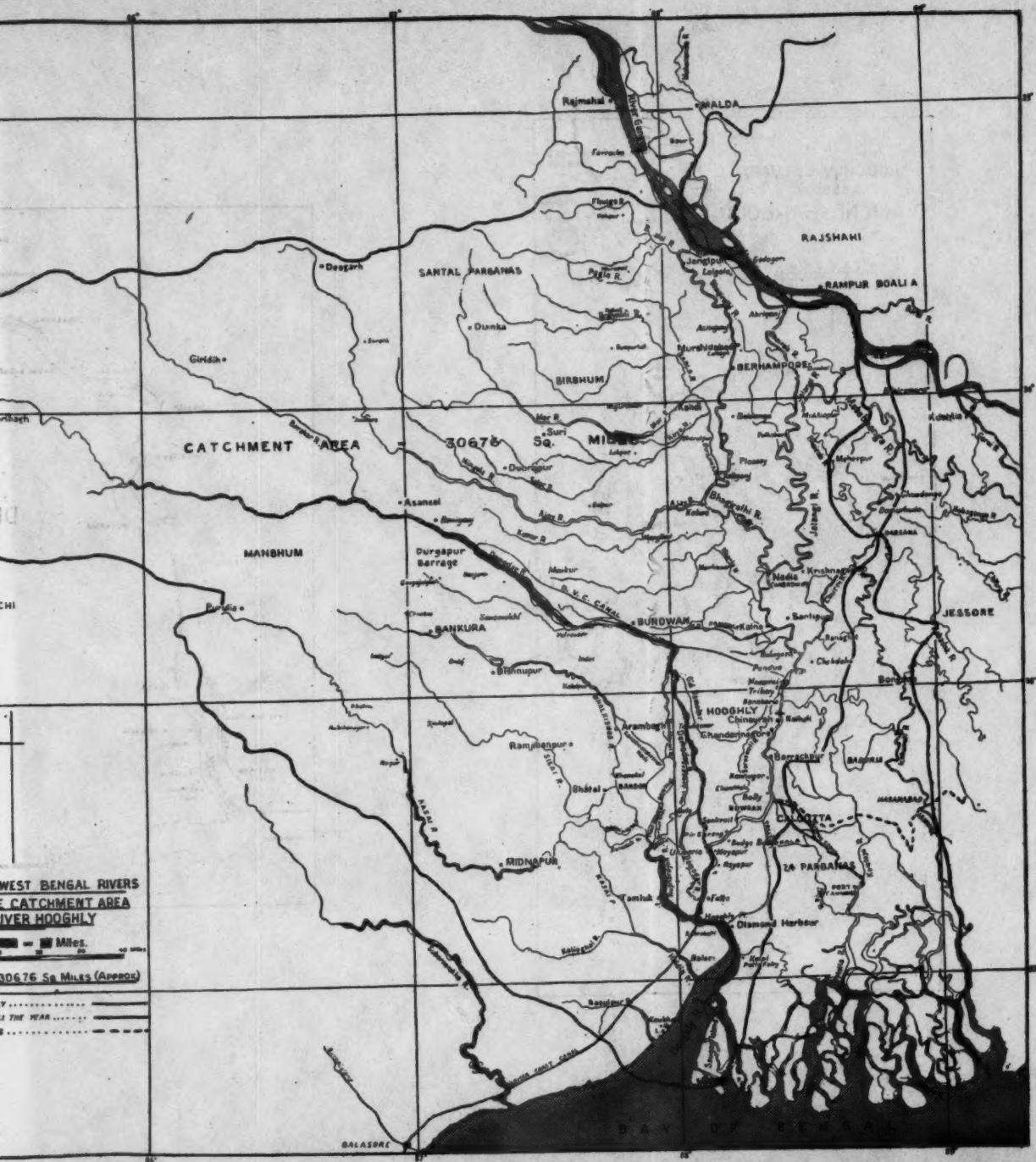
Moyapur and Royapur Bars are the next obstacles above the Fulta Point area and are typical of bars developing where concavity changes over from one to the other. While in non-tidal rivers the position of the bar remains static provided the river does not develop fresh meanders due to increase in domi.

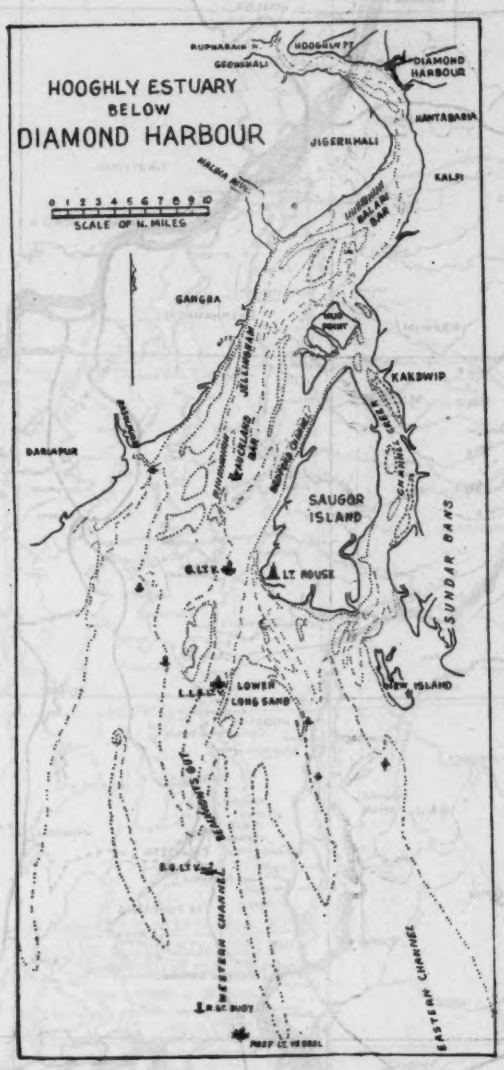
PLATE No. I

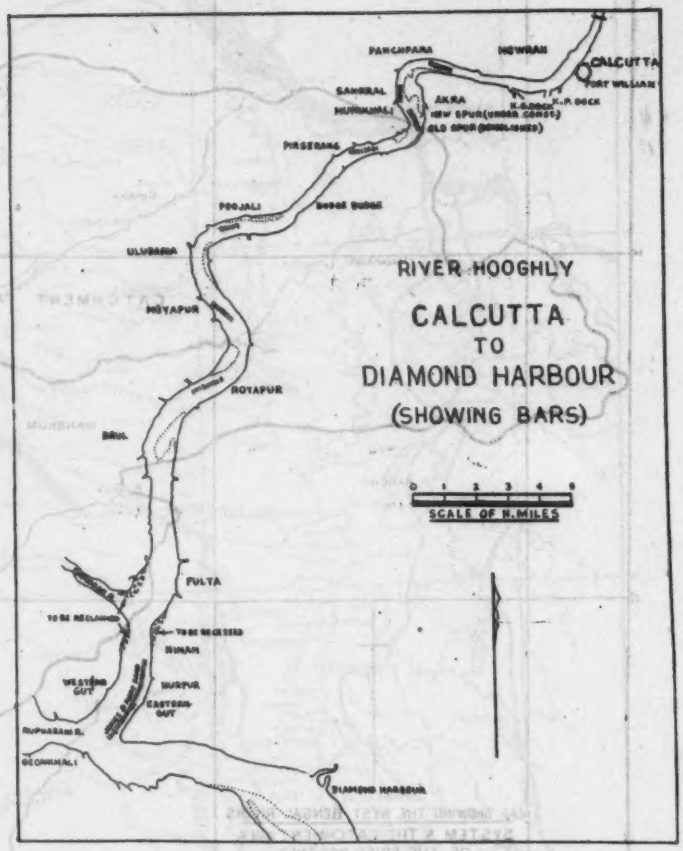

MALDA
Rajmahal
SANTAL PARGANAS
Deogarh
Dumka
Giridih
BIRHBHUM
BERHAMPORE
Hazaribagh
CATCHMENT AREA = 30676 Sq. MILES
Asansol
Durgapur Barrage
D.V.C. CANAL
MANBHUM
RANCHI
Purulia
BANKURA
BURDWAN
Bishnupur
HOOGHLY
Arambagh
Ramjibanpur
MIDNAPUR
BALASORE
MAP SHOWING THE WEST BENGAL RIVERS SYSTEM & THE CATCHMENT AREA OF THE RIVER HOOGHLY
Scale ■■■■ = ■■ Miles.
CATCHMENT AREA = 30676 Sq MILES (APPROX)
INDO-PAKISTAN BOUNDARY
STEAMER ROUTES USED ALL THE YEAR
FEEDER STEAMER ROUTES

ATE No. I


RANCHI
MAP SHOWING THE WEST BENG
SYSTEM & THE CATCHME
OF THE RIVER HOOG
Scale
CATCHMENT AREA = 306.76 Sq Mi
INDO-PAKISTAN BOUNDARY
STEAMER ROUTES USED ALL THE YEAR
FEEDER STEAMER ROUTES


MALDA
RAJSHAHI
SANTAL PARGANAS
RAMPUR BOALIA
BERHAMPORE
BIRBHUM
CATCHMENT AREA
30676 Sq. MILES
MANBHUM
Durgapur Barrage
BANKURA
BURDWAN
JESSORE
HOOGHLY
MIDNAPUR
24 PARGANAS
Diamond Harbour
BAY OF BENGAL
BALASORE
WEST BENGAL RIVERS
CATCHMENT AREA
RIVER HOOGHLY
Miles.
30676 Sq Miles (Approx)


HOOGHLY ESTUARY
BELOW
DIAMOND HARBOUR
SCALE OF N. MILES
DIAMOND HARBOUR
KANTABARIA
JIGERKHALI
KALPI
GANGRA
KAKDWIP
DARIAPUR
SAUGOR ISLAND
LT HOUSE
SUNDAR BANS
LOWER LONG SAND
WESTERN CHANNEL
EASTERN CHANNEL


PANCHPARA
HOWRAH
CALCUTTA
FORT WILLIAM
SANKRAIL
AKRA
H.P. DOCK
PIRSERANG
POOJALI
BARGE BUNDS
ULUBARIA
RIVER HOOGHLY
CALCUTTA
TO
DIAMOND HARBOUR
(SHOWING BARS)
ROYAPUR
BAUL
SCALE OF N.MILES
FULTA
DIAMOND HARBOUR

hant discharge or sand charge, in tidal rivers the bar shifts according to the current in preponderence. The tidal inflow intends to develop a channel closer to the convex bank while the ebb current attempts to develop a channel closer to the concave bank. Dredging is carried out at these bars to assist nature to maintain a channel as near to the axis of flow of the two tidal currents as possible and to maintain navigable depths in the transition period between the two seasons.

In the stretch of the river between Calcutta and Moyapur we have five bars known as Low Water Crossings because light draft outward bound ships cross these bars on the last of the ebb tide, so as to get over Moyapur and Royapur bars on the rising tide. The depths on these bars have consequently got to be greater than others. Sankral and Munikhali bars are the worst of these and have been giving considerable trouble in recent years, especially Sankral.

Plan of the River

A study of the plan of the river brings forth the following salient features of this area (*i*) the river is too wide, in fact is the widest from Calcutta to the confluence of Rupnarain river with the possible exception of the Fulta Reach, (*ii*) it has the unusual configuration of having both banks concave and (*iii*) it has short bends above and below.

The left bank has been progressively eroding over a period of years and has now assumed this abnormal concave bulge. The lines of flow of the two channels are divergent in the extreme, the ebb current hugging the right bank while the tidal inflow flows strongest towards the left bank leaving the right bank channel a region of slack velocity. The channel therefore shoals considerably in the dry season and has been progressively deteriorating in recent years

Model experiments to investigate the method of improvement of the navigability of the river Hooghly to achieve the target of a minimum draft of 26 feet on any day of the year have been in progress for the past six years. These experiments have revealed that the adoption of certain remedial river training measures to correct the divergence of axes of the two tidal currents will considerably reduce the present impediment and difficulties to navigation at the various troublesome stretches of the river. The Expert Committee, appointed by the Government of India, have unreservedly endorsed the conclusions so far reached on the model experiments and have stated that the results in the way of location and alignments of various training measures should be acceptable with complete confidence. They have also emphasized the urgent necessity of restoring the perennial supply of headwater to the Hooghly.

The construction of a spur at Sankral to correct the faulty configuration of this reach was commenced in December 1953. The full length of the spur has been completed and the present operations are devoted to constructing the nose with the apron round it, which has to be built to resist the erosive and destructive forces of the current from undermining the spur.

The new spur has given every indication of fulfilling the predictions regarding its utility. The deflection of the tidal inflow towards the navigable channel is smooth and the lines of flow are similar to those indicated in the model. Accretion has already commenced quite noticeably both upstream and downstream on the Akra side indicating the river will assume the necessary convex curvature the Akra bank should have in a couple of seasons.

Model experiments for the improvement of Fulta-Hooghly Point area (most troublesome stretch of the river) have been concluded. Briefly the measures are (1) Recession of the protrusion of the left bank at Fulta so as to maintain a uniform concavity all the way from Fulta to Eastern Gut Bar and (2) Termination of concavity upstream and downstream of the outfall of the Damodar by reclamation. These measures will ensure the Hooghly ebb flowing along Ninan channel and prevent its deterioration in the freshets. It will also induce the tidal inflow into Fulta considerably improving this reach. The recession of Fulta Point by canalising ebb flow down Eastern Gut Bar, will increase the ebb velocities in the dry season thereby minimising the dredging required to maintain this bar.

C.A. Parsons & Co. Ltd.—Transformer Production

As an indication of the wide range of transformer production at the Heaton Works of C.A. Parsons & Co. Ltd., Newcastle Upon Tyne, England, two orders just completed are worthy of note.

C. A. Parsons are one of the largest British manufacturers of mining type transformers. Recently they have completed several units which are to be installed underground in a colliery in Nova Scotia, Canada. The transformers are rated at 400 KVA 6,600/2,200-550 volts 3 phase 60 cycles. The alternative voltages on the low tension side are obtained by means of a linking arrangement accessible through inspection openings in the tank cover.

A circuit breaker, incorporating overload and earth fault protection and equipped with flit plug is mounted on the 6,600 volt end of the transformer and, due to the large current when operating on 550 volts, the L. V. air filled chamber is provided with two flit plugs.

At the other end of the scale Parsons also manufacture high voltage power transformers and have just delivered the largest three phase unit to be connected to the British Central Electricity Authority's super grid. The transformer (one of two similar units being supplied by Parsons) is rated at 120,000 KVA 275/66/33 KV, is equipped with ON/OFB type cooling and, due to the three windings, the equivalent frame rating approaches 150,00 KVA. The transport weight was 165 tons and the total weight on site, complete with oil, 234 tons. The transformer was fully tested at Heaton Works before delivery to site, the tests including an impulse test.

Rivers of West Bengal and Control of their Floods

By

R. B. CHAKRAVARTY

Superintending Engineer, Irrigation and Waterways Department, Govt. of West Bengal

AUTHOR

The author whose work in the Mayurakshi Project is welknown has surveyed here briefly the problem of floods in the three distinct types of rivers in W. Bengal, namely, Rivers rising from the Himalayas, Rivers rising from Chotnagpur and Santhal Parganas hills, and the Tidal Creeks and suggests in broad outline the different methods of flood control that may be applicable in the case of the respective groups of rivers. It is interesting to note that engineers are now increasingly aware of the importance of soil consvervation and afforestation measures in meeting flood problems.

As we all know the work of rivers may generally be divided into three zones. In the upper zone where the slope is usually the maximum, the bed and banks are secured and the action is therefore, destructive ; in the midzone the denuded soil is transported and in the lowest reaches, where the rivers meet the sea or lake, the slope is very flat and the soil so carried is deposited in the bed and banks forming plains like the Gangetic delta. The plains are the land of best productivity, and, therefore, from the point of view of formation of plains (delta formation) transportation and deposition of soil is essential. On the other hand if denudation is fast, it may mean removal of coarse soil, not yet completely disintegrated, the deposition of which is harmful to the land. Besides, deposition of soil at a very fast rate changes the topographical condition so much that the flood levels of particular zones are affected seriously. When such conditions develop, the beds of rivers as also the high flood levels rise rapidly and within a short period the river becomes a source of potential danger. It is at this time that we feel the necessity of controlling floods in such rivers ; particularly, if alongside the river banks vested interests had grown meanwhile. A well-designed canal has just the gradient necessary for the flow of water along with the silt it contains and the canal is then in regime. In the case of a river this is far from being so. The discharge varies according to the intensity of the rainfall or melting of the snow. The silt content varies widely depending on the nature and condition of the soil and forest cover in a particular portion of the catchment where the rainfall is concentrated. As a result, river sections are rarely in regime. In alluvium they are usually of greater widths than required for the normal discharge. For smaller discharges therefore, the river is much less efficient hydraulically and, therefore, silt is deposited quickly as soon as the river, coming out of the hilly gorges, meets the alluvial tracts in the terai. The bed of the river in this tract therefore rises. In some cases the rise is so much that the bed is higher than the adjoining countryside level. Under these conditions the river may out-flank its banks any time and take a completely different course where the operation is repeated.

Flood Control Methods

The aim of flood control of a river is to ensure that the river is maintained within its banks and to prevent from doing any harm to the countryside (either to the land or to other vested interests).

Rivers have their own characterstics and, therefore, the flood control methods also vary from river to river and place to place. The controlling works may be of various types.

(1) *Series of Weirs across the rivers* :

These have the effect of flattening the gradient of the river and fixing the lower limit of bed scour which help in reducing land-slips also. The silt contained in the river flow is thereby greatly reduced. If these weirs are given restricted openings, they have the flood absorption effect in addition.

(2) *Storage Reservoirs:*

These act in the same way as the series of weirs mentioned above. Besides, these also act as silt-traps until they are fully filled up with silt.

(3) *Construction of Embankments (Levees):*

The purpose of construction of embankments is to keep the river within its banks and prevent from doing harm to the adjoining countryside. Except where the silt content is unusually high, an empirical relation may be found out between the average discharge, average silt content, bed width and depth of a channel. If these conditions are applied and the embankments correctly aligned, it may be possible to canalise a river so that there may not be any appreciable deposition of silt and rising of bed level. But maintenance of such embankments in the rivers having high silt charge will be extremely difficult on account of the fact that the river section will have to be narrowed down (for inducing strong current for transport of the silt charge) which will result in bank erosion unless the banks are suitably protected with protective works which may consist of boulder pitching with apron, or sausage work, of concrete blocks pitched etc. These works are rather costly and uptil now are not known to have been undertaken in this country (on an appreciable scale) for the purpose of channelising a river with a view to improving its hydraulic condition. Works of this nature have, however, been undertaken in local areas in this country for protecting important places, which is not a permanent solution of the problem.

(4) *Afforestation:*

Since the condition of the river deteriorates only by the silt, it will appear that if the movement of silt could be restricted within reasonable limits, many of the problems will be solved. The role of the forests in this respect is invaluable. The forest encourages vegetation cover on the soil, which keeps soil particles intact and the two combined together have the effect of absorbing a considerable portion of rainfall, thus reducing the total run-off as also peak discharge during each concentrated precipitation. Besides, the vegetation cover protects the soil being denuded from the action of the wind and rain. Leaves of trees also have the effect of absorbing energy of the falling water and limiting its damaging effect on the soil.

(5) *Control of Rainfall:*

Uptil now the researches made in this respect have only shown the possibility of melting a cloud by artificial means but nothing appears to have yet been said about how to exclude concentrated rainfall in a particular area eliminating the risk of local high floods.

Rivers provide a number of conveniences; towns, factories, business areas and other vested interests, therefore, grow alongside the banks of rivers. This development of the banks creates a problem in rivers whose beds are in the process of rising, as once these interests grow, it is not feasible to allow the floods to pass over the lands uncontrolled and, therefore, protective works like embankments are to be constructed. The floods then being restricted within the banks leave the silt to accumulate on the bed, raising it gradually. Often the bed rises above the adjoining countryside level and then it becomes extremely difficult to maintain the embankments any further, except at excessive cost.

Rivers of West Bengal

Leaving aside the Ganges, rivers in West Bengal may generally be divided into the following three groups and the best methods of controlling floods will depend on the condition of the river and its catchment area.

(*A*) *Those rising from the Himalayas* :

Are generally snow fed and also have their catchments under the influence of the strong southwest monsoon during the rainy season

These rivers are characterised by high run-off owing to the heavy precipitation during the monsoon. The silt charge is also very high on account of steep hill slopes, steep surface gradient of the river in the hilly zones and poor quality of rock and soil in the catchment. These rivers usually have perennial discharge although the discharge is comparatively small during the dry season

In the past floods are known to have caused trouble in a very large tract of terai area of North Bengal. But the floods of 1954 exceeded all proportions. Accordingly, a survey party was sent to make a preliminary investigation in the catchment area. They have noticed heavy land slips (apparently due to loss of vegetation and forest cover and steep hill slopes etc.) in the catchment. Concentrated rainfall area also is known to have occurred and the combined effect of these two along with other minor factors appears to be the cause of the slips. Heavy land slips sometimes completely block the passage of the rivers in gorges where a temporary natural storage dam is created which is gradually filled up, over-topped and breached in its natural course. Such a breach would give rise to a disproportionately high flood and this must also have been at least one of the reasons of such high floods.

That floods in the past have passed through many of North Bengal towns like Jalpaiguri is manifest in the fact that buildings in these towns were constructed with high plinth on timber posts or pillars and hardly any 'pucca' structure with closed plinth was noticeable about 25 years back. Since then, however, considerable number of 'pucca' structures with closed plinth have been constructed in these towns and hence, they find themselves in extreme difficulty now as flood water being obstructed by closed plinthed structures in the towns do not get the opportunity of having its elevation reduced quickly during its passage over the countryside.

On account of the financial question, practically nothing was done in respect of floods in these rivers, but the recent floods were serious enough to have drawn everybody's attention. The problems have thrown a challenge to the engineers. The solution is not an easy one. The works that are being undertaken now consist only of the protection of the more important towns but this is only a short term benefit, as unless the river conditions are improved, the bed will gradually rise and in course of a limited number of years these protective works may require further raising and ultimately be ineffective. A more reasonable known method will probably be to aforest the barren portions of the catchment area in the first instance. Construction of a series of weirs or storage reservoir at suitable sites may also be undertaken in respect of the major rivers.

(*B*) *Rivers rising from Chotnagpur and Santhal Parganas Hills*

Rivers of group B remain practically dry during winter and summer, and the discharges in these rivers are also comparatively low during most part of the rainy season except during high floods (lasting for periods from a few hours to a few days, depending upon the extent of the catchment under heavy precipitation) when the discharge increases out of all proportions. These rivers also carry silt, but usually smaller in quantity than the rivers of the first group.

Floods of 1943 in the district of Burdwan affected Grand-Trunk road and both the railway lines (Main line and H.B. Chord) and all attempts of the parties concerned failed to maintain communications during the whole of that rainy season. Similar floods were also known to have caused damages in previous years, (although usually to a lesser extent). Proposals had been made in the past to resort to flood control by reservoir absorption, and various surveys and estimates had been prepared from time to time, but apparently, as such projects cost considerable amounts of money without the prospect of any direct revenue derived from it, they were shelved. After the floods of 1943, however, the idea had to be revised and old schemes had to be raked again. To overcome the difficulty of meeting the cost, these storage dams were being made multipurpose so that a major part of the cost is re-

covered from its revenue accruing benefits. The Project investigations were started afresh on these lines from 1944, and ultimately the D. V. C. was created, as we know, for their execution.

The flood control works of the Damodar Valley Project consist of construction of a number of flood control reservoirs. Proposal for aforestation in the catchment area are also incorporated therein.

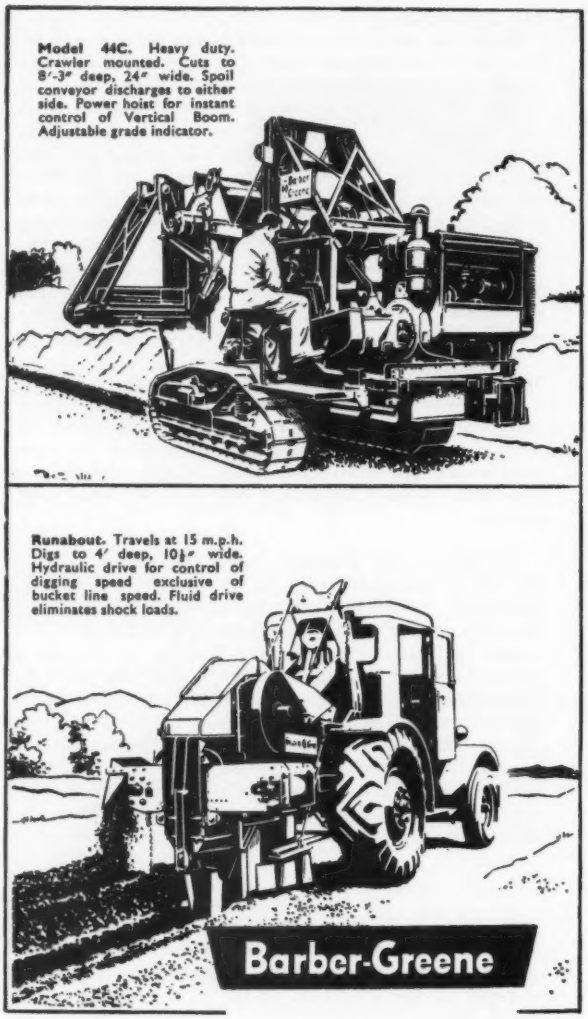
In the case of the rivers rising from the Chotnagpur and Santhal Parganas hills one would notice that considerable amount of cultivation are made every year at the foot of the hills by ploughing the sloped ground but wothout terracing it. As a result each year a large quantity of soil is denuded and carried into the rivers increasing the silt content therein. The reservoirs will, therefore, have a very limited life unless this method of cultivation is immediately brought under control.

(C) Tidal Creeks in South Bengal

Rivers of the third group are tidal and floods rise periodically during spring tides particularly during the equinoxas (vernal or autumnal). These rivers being in the deltaic zone, the problem of flood control does not raise until the area is reclaimed for cultivation or for other pruposes.

The reclamation procedure adopted by private parties is to construct embankments (levees) along side these rivers to prevent tide water entering their lands. The lands are drained during ebb-tides through tidal sluices. The problem is comparatively easy as it only means putting up strong embankments to stand the highest water level and wave action. If a complete block of area is proposed to be reclaimed, it is more convenient to put up a sea-dyke closing the tidal creeks in the area and draining the local run off through sluices. If the land is reclaimed prematurely, i.e., the formation of the delta is not so high as to encourage natural drainage during ebb tides, pumping may have to be resorted to, particularly when the bed of the adjoining drainage channel rise in due course, as had to be done in the case of Sonarpur-Arapanch area. With the availability of cheap electricity now-a-days it is not a very difficult work This procedure is, however, not convenient when there is upland flow of water into the area.

In the case of the rivers of North Bengal and those rising from Chottanagpur and Santhal Parganas hills, it will appear that a more permanent effect may be obtained if the growth of forest over all barren lands, hill sides etc. is ensured and unterraced cultivation reduced to the minimum. Unfortunately, most rivers have catchments in a different country or State than those affected by their floods. It is not therefore unnatural that there will be some difficulty in the matter of afforestation. Besides, in the present land tenancy system it is not possible to control unterraced cultivation. In the case of rivers having catchment areas in States other than those flooded by them, measures may be taken effectively only by the supreme authority of the country, whereas, in the case of catchment areas of rivers lying outside the country flooded the position is extremely difficult, as only an international body can exercise some control.


Model 44C. Heavy duty. Crawler mounted. Cuts to 8'-3" deep, 24" wide. Spoil conveyor discharges to either side. Power hoist for instant control of Vertical Boom. Adjustable grade indicator.
Runabout. Travels at 15 m.p.h. Digs to 4' deep, 10½" wide. Hydraulic drive for control of digging speed exclusive of bucket line speed. Fluid drive eliminates shock loads.
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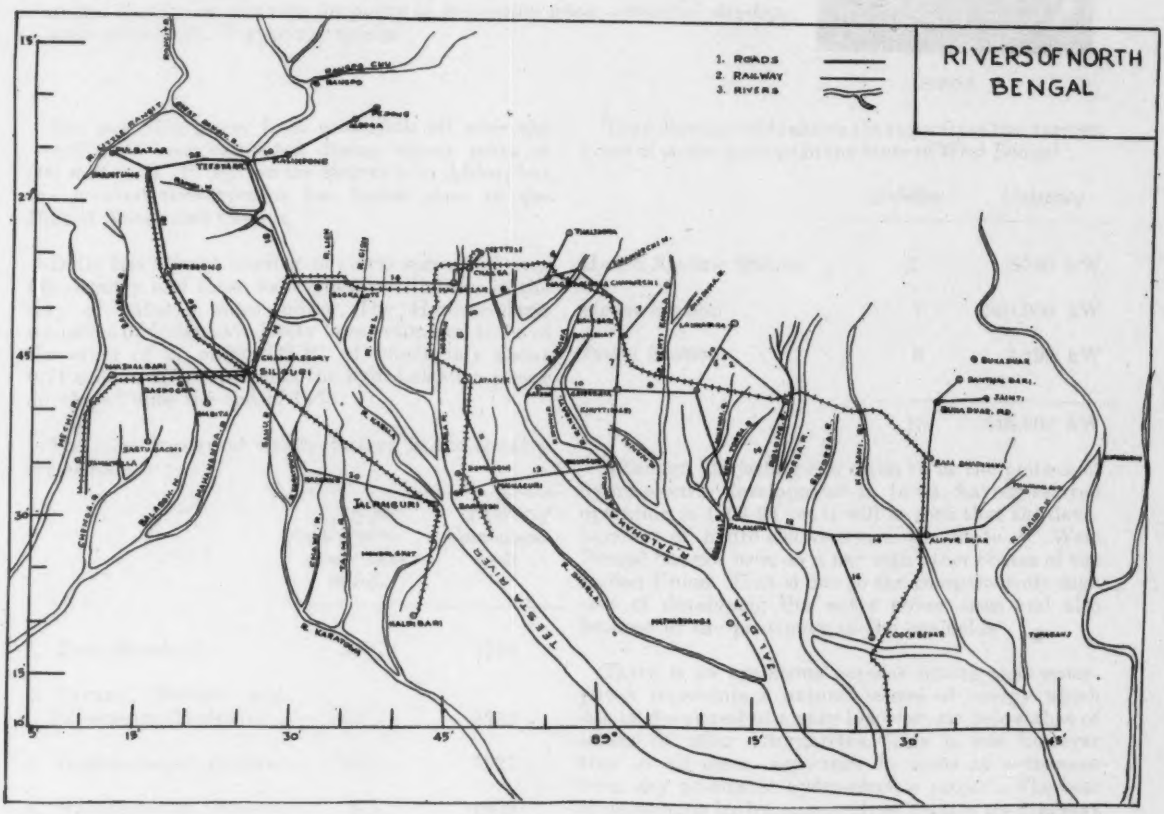
RIVERS OF NORTH BENGAL
1. ROADS
2. RAILWAY
3. RIVERS
SILIGURI
JALPAIGURI
COOCH BEHAR
ALIPUR DUAR
HALDIBARI
MATHABHANGA
TEESTA
TORSA
JALDHAKA
RAIDAK
27°
45'
30'
15'
89°
15'
30'
45'

Power Development in West Bengal : Hydro and Thermal

By

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West Bengal State Electricity Board, Govt. of West Bengal

AUTHOR

In this brief article Dr. Datta surveys the power development possibilities in W. Bengal, with special reference to hydro-electricity and points out the necessity of an integrated development programme of W. Bengal's rich water resources for power and irrigation. The State's coal reserves are also considerable and are of a rich variety. The two together should prove of immense possibilities to feed the leaping demands for power in this region whose industrial development programme is growing rapidly.

The available power from walterfalls all over the world have been estimated during recent years at 500 million H. P. By far the largest is in Africa, but the greatest development has taken place in the United States and Canada.

India has a large number of rivers spread all over the country and these have great possibilities in the way of natural water power. The Hydro-electric resources of India have lately been estimated to be of the order of 27 million H.P., of which only about 0.71 million kW. represents the hydro-electric power developed upto the end of 1953.

The most important hydro-stations in the country are as follows :—

	% of the total hydro-power installed.	*Year of Commencement*
1. Tata (Bombay) ..	50%	1916
2. Pykara, Mettur and Papanasam (Madras) ..	20%	1932
3. Jogindernagar (Punjab)	10%	1927
4. Sivasamudram (Mysore)	8%	1902
5. Pallivasal (Travancore)	7%	1935
6. Ganges Canal (Uttar Pradesh ..	4%	1936

All the above hydro-electric schemes except Mettur involved power development only, while at Mettur a dam constructed on the Cauvery river impounds 93,500 million cubic ft. of water primarily for irrigation and a portion thereof is utilised for power generation to make the hydro-energy really cheap and profitable. The other areas are deficit in coal supplies but hydro-power could be easily and economically developed to the exclusion of other forms of electric power generation because nature has planted a great quantity of water at such elevation that it can be easily and effectively utilised.

The following table shows the capacityof the various types of power stations in the State of West Bengal :

	Number	*Capacity*
Hydro-Electric Station ..	2	2,760 kW
Steam Station ..	7	540,050 kW
Diesel Station ..	9	3,192 kW
	18	546,002 kW

Although Darjeeling can claim to be the pioneer of hydro-electric development in India, having started operation in 1897-98 yet it will be seen that the development of hydro-electricity in the State of West Bengal has not been on a par with other States of the Indian Union. That is due to the comparatively high cost of developing the water power sites and also because of the proximity of the coalfields.

There is an erroneous popular notion that water-power represents a natural source of energy which can be developed at a very low cost, far below that of steam or other alternatives. This is not however true in all cases, especially in areas at a distance from any praticable hydro-electric project. The cost of developing hydro-power varies greatly for different regions ; and again the cost of transmission of the power so generated to the load centre may be a determining factor.

While comparing the steam and hydro-power stations, two important considerations should be taken into account. These are:

Firstly, the coal reserve of India is limited and the use of water power will save much coal. Secondly, a combination of thermal and hydro-power generally gives better performance and provides power at a lower total cost than would be the case if supply is provided to any large inter-connected power supply system wholly from either one or the other.

Considering the above in West Bengal, where both the hydro and thermal power resources are available,

the two sources may be considered as complementary rather than competitive and ways and means should be found to develop hydro-power in this State, having due regard to the secondary effect which its construction will have upon the economy of the State.

For proper appreciation of the 'Rivers in West Bengal for hydro-electric generation,' it would be convenient to classify the rivers into the three following groups :

Group—I. Under this group should be classed, the rivers of the Gangetic plains which have their sources in the distant mountain and flow for hundreds of miles before entering the plains of Bengal maintaining a more or less perennial flow and navigable all the year round. The Ganges is the largest of this group of rivers draining an average annual rainfall of 42 inches over a catchment area of 3,97,500 Sq. miles and with a recorded discharge of about 2,000,000 susecs. But the Gangetic plain being absolutely flat, the rivers in this region cannot to utilised for hydro generation.

In the lower deltaic region, however, there are a number of estuaries, each resembling an arm of the sea, where the possibilities of obtaining power from the tides may be explored. But, even in this regard, a distinguished engineer has said, "Power by rise and fall of tide will always be alluring but disappointing." Only four modern proposals to use the tide are known, but none of them has made any great headway and consequently it is not looked upon as a source of power at present.

Group—II. This group consists of rivers, such as the Subarnarekha and the Cossye in Midnapore district ; the Silai and Dwarakeswar in Bankura district and the Damodar, the Ajoy, the Mayurakshi, the Dwarka, the Pagla, The Brahmani etc. in Burdwan, Birbhum and Murshidabad districts. They run more or less from West to East, each independent of the other. These rivers have their sources in the Chotnagpur and Santhal Parganas hills. With the advent of the monsoon rains (months of June to September), they bring in enormous volumes of water at times, cause destructive floods. They, however, dwindle down to a mere trickle, sometimes even during the rainy season and during the dry season there is practically no flow.

The Damodar is the typical example of this type of rivers, the flow of which varies from 1/2 cusec (March) in the dry season to 60,000 cusecs or more in the monsoon, which frequently caused devastating floods resulting in great loss of life and property, the last being that of 1943. The Ajoy which lies further north, becomes completely dry in May and discharges over 12,000 cusecs of water in August.

It is, however, to be noted that the times of occurence of the floods do not always synchronize with the time when irrigation is required, especially after the middle of September when the rainfall is hardly sufficient to meet the requirements of the paddy. Even in normal years, artificial irrigation is thus a necessity in these districts to ensure a normal harvest. It is, therefore, apparent that to meet the irrigation needs of the area, storage is a necessity. But, owing to the flatness of the country, it is difficult to obtain suitable sites for storage dams within the boundaries of the State. Good sites are, however, selected in the upper valleys of the rivers lying within the hilly regions of Chotnagpur and Santhal Parganas, where, for storage of flood waters from the rainfall of the catchment area, large reservoirs and dams are being built in connection with the Damodar and the Mor projects.

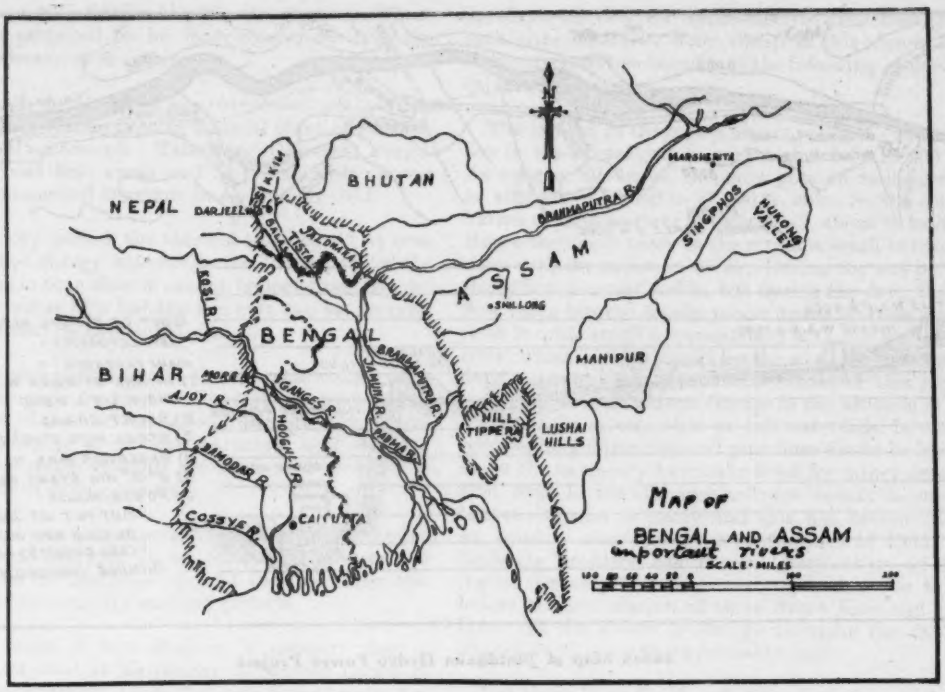
In the case of Damodar, the rainfall in the catchment area of the Damodar Valley passes through the Damodar, Barakar and their tributaries Konar and Bokaro and is proposed to be harnessed at eight storage dams for floods control. It was also realised that the control of the river would not only prevent the recurrence of devasting floods but would also provide for regular irrigation, navigation in the area and also for the production of hydro-electric power.

It has, therefore, been proposed to install hydro-electric generating plant as indicated below :—

Barakar River		*Damodar River*		*Tributories of Damodar*	
Thaiya	4,000 kW.	Aiyar	45,000 kW.	Konar	40,000 kW.
Balpahari	20,000 ,,	Bermo	30,000 ,,	Bokaro	3,000 ,,
Mathion	40,000 ,,	Panchet Hill	40,000 ,,		
Total	220,000 kW.				

These stations will not be constructed simultaneously. Works are in progress at Maithon and Panchet Hill. Approximately one half of this capacity will be firm power at 60% load factor and the rest seasonal. In order to augment the seasonal power, a thermal station has been completed at Bokaro with an immediate installed capacity of 150,000kW and an ultimate capacity of 225,000 kW. By the end of 1957-58, when all the D.V.C's Projects (first phase) are completed, power will be available to Gaya, Patna, Dalmianagar and Calcutta, besides the Damodar Valley basin, whch comprises the districts of Hazaribagh, Manbhum, Singhbhum, Ranchi and Burdwan.

At Durgapur, the site for the new Coke-Oven Gas Grid plant, plans for installation of two new thermal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GANGES R.
JAMUNA R.
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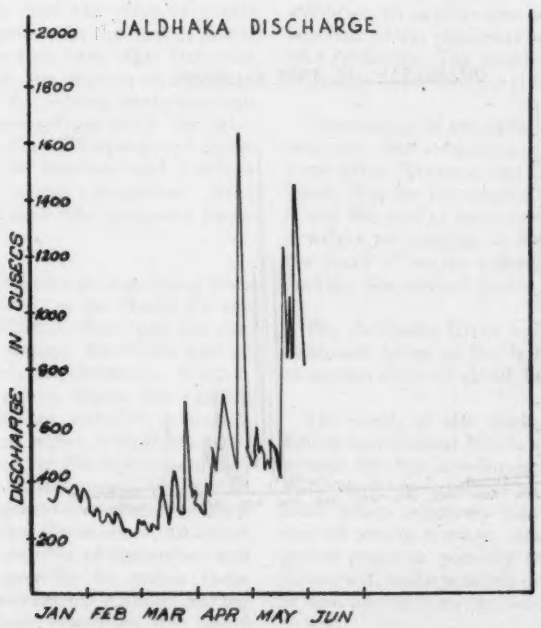
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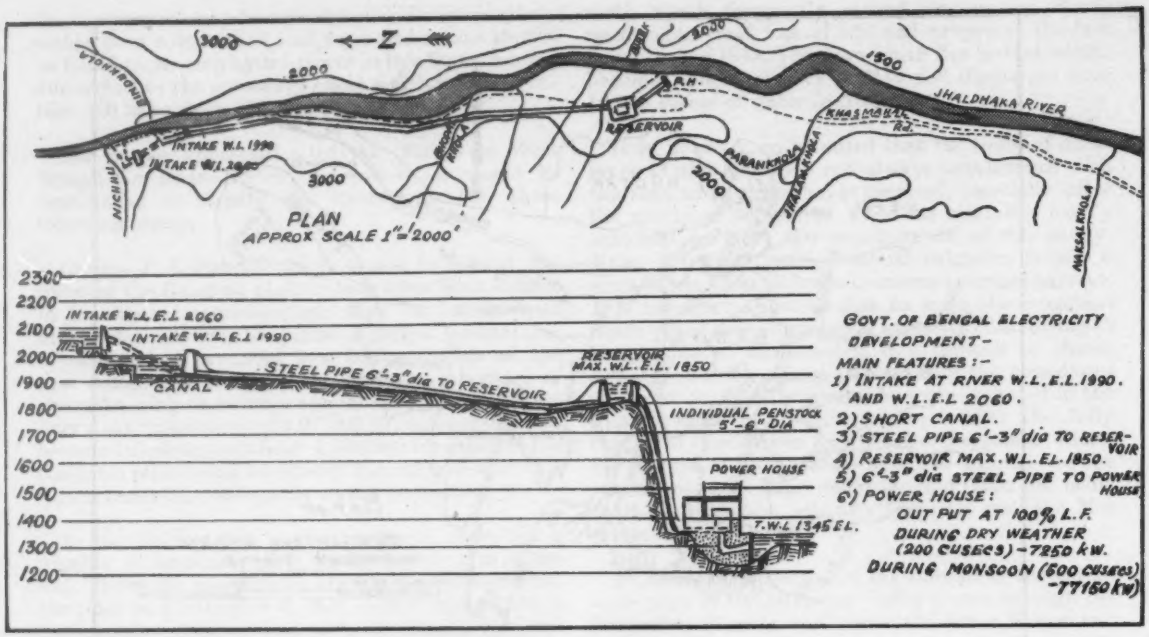
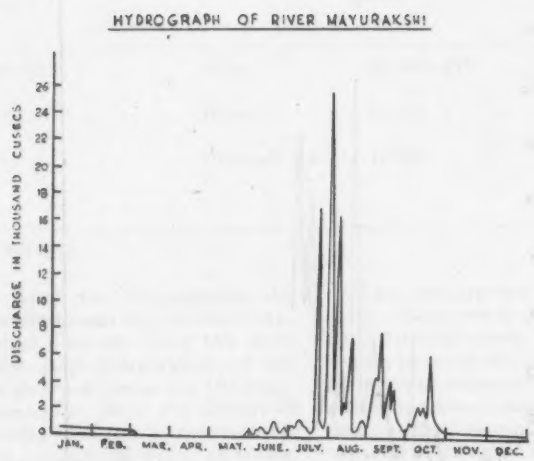


Index Map of Jhaldhaka Hydro Power Project



plants have been finalised by the Gevernment. These plants are proposed to be inter-connected with the D.V.C's transmission system.

When all the schemes are completed, we get the best possible system having thermal plant of suitable size at load centers viz : Tatanagar, Calcutta, Durgapur and coal field areas and available hydro-power stations connected together in a common Grid.

During dry period, the thermal stations act as base load, as the energy content in the lower part of the load curve is such that it cannot be met from the dependable water flow but the top part can be conveniently supplied by hydro-stations.

During wet period again, the thermal stations are worked as peak load, as the energy content in the lower part of the load curve could be met with hydrostations working at or near maximum load continuously. The steam stations are then used as little as possible, thus saving the coal.

In actual practice, the installed capacities of hydro and thermal stations in an integrated sustem are worked out on the basis of load sharing under the worst conditions in dry and wet periods.

In the case of Mor Project, a masonry dam is being constructed at Massenjore in Santhal Parganas capable of collecting 0.5 million acre feet of water for controlled distribution throughout the year. This storage will be primarly for irrigation ; but a proportion, viz. about 300 cusecs will be available throughout the year for hydro-electic generation with an additional discharge of about 300 cusecs during monsoon, i.e., July to October. Here the power production will be an adjunct of gravity irrigation. The whole cost of civil engineering is proposed to be allocated to irrigation only, so that the price of power will be low enough to compete with the cost of power from other sources and in this case, the Damodar Valley Corporation's system, the sharing of the large capital outlay on the Civil Enginering works between power, irrigation and flood control has made the price of power to be competitive also. The proposed figure for allocation in the case of Maithon and Panchet Hill sites are 1 : 1 : 4 for power : irrigation : flood control. For Tilaiya and Konar, the proposed figure for power is 60%.

Group—III. This rivers under this group, rising from the Himalyan region, bordering in the North for the most part in Sikkim and Bhutan, flow into the districts of Jalpaiguri and Darjeeling. The Tista and all others, which flow east of it viz. the Jaldhaka, Raidak, Gangadhar belong to this group. There the rainfall is heavy. Besides, the thickly wooded mountain retains much of the monsoon water, so that considerable discharge can be obtained in the dry season also. These rivers have great potential power for hydrogeneration. Some of the larger rivers, which are snow fed, give good discharge during the summer, although the flow is least during the months of December and January. It is, therefore, possible to utilise these group of rivers for power generation without having to construct dams to form large reservoirs but based on the minimum flow.

The above may lead one to the conclusion that the development cost for hydro-electric generation from such sites would be very cheap in this region. This is, however, not so because of the following geographical characteristics.

The rainfall in the region also is seasonal. The snow lies in the Himalayas in very high (about 10,000 ft.). As summer advances, the snow goes on melting upto an altitude of 16,000 to 17,000 ft. only. So the contribution of snow to river flows is small, about 10 to 20%. Hence the snow water in the rivers is small in comparison with the monsoon water. During the wet period, the inflow is considerable, but during the dry,, the inflow being less the steady power available from such a river is quite small in comparison with the size of the river, which is determined by the available maximum flood capacity. Another characteristic of this region is that there is no abrupt change in the altitude in the course of the rivers, what we call waterfalls. In consequence, long flume line and pipe lines are to be laid to make the necessary hudraulic head for power generation. Such laying of flumes and pipe lines in the mountaneous terrain is costly and this has become more so, because after the great earthquake of 1952, the landslide problem has become very acute in this region. Great precautions are required to be taken before the installation of these flume lines and pipe lines. All the above factors go to make the capital cost of such projects appreciably high.

But there is no likelihood of power being available from any alternative major thermal power plant, as the cost of transport of coal will be excessive because of the lack of good communication. Thus the hydropower in this region will have to be regarded as the only source of power in this Terai and Western Duars Areas.

The Government of West Bengal have recently given attention to explore the possibility of economic development of the smaller river sites viz. that at Balasun and Jaldhaka. The present load prospect is sufficient to justify these smaller river schemes.

Harnessing of the other larger rivers like the Tista may not offer attractive or economic prospects, unless some large factories can be set up in the neighbourhood. But for the control of the North Bengal flood, if any Scheme of construction of dams is carried out, it might be possible to utilise, for power production, the head of water behind the Dam or Dams, thus making the cost of power relatively cheaper.

The Jaldhaka River has its origin in several small mountain lakes on the border of Sikkim and Bhutan at an elevation of about 14,000 ft.

The reach of the Jaldhaka River between Bindu Khola and Naksal Khola appears to offer good possibilities for the development of hydro-electric power. This reach, in addition to containing a considerable head, offers relatively easy access to the site. Provision of ample storage, either immediately above the power plant or possibly further up on the Jaldhaka River, will make possible development of large amount of firm power from the Jaldhaka and adjoining small rivers.

A scheme for developing the head in the upper part of this reach (600 to 800 ft.) was prepared by the

Electricity Development Directorate in April, 1947 with a view to supplying power to the numerous tea gardens in the Dooars, involving power transmission over short distances.

It was proposed to collect water of the Jaldhaka River near the point of entry of the Bindu-Khola near the Boundary of Bhutan, then conveyed by a 6'3" diam. steel pipe line to a series of old river terraces known as Gouringong, then lead to a surge chamber and forebay and afterwards by individual power pipe to each generating unit in the Power House at a place known as Paren. Based on water-measurements carried out by the River Research Institute, a minimum flow of 200 cusecs can be assumed for design and by the utilisation of drop from Bindu Khola to Biru Khola could make an amount of firm power of 7,250 to 10,400 kW. at 100% load factor or 11,700 to 16,900 kW. at 60% load factor depending on the layout chosen.

In appears that the energy generated in the Jaldhaka will be consumed more or less locally in the surrounding territory. Stage-wise development of the Jaldhaka and adjoining smaller rivers commensurate with prospective growth of load will probably not entail heavier financial commitments than can be borne without becoming a burden.

In conclusion, integrated effort should be made by all departments connected with the development of the rivers of West Bengal, such as Irrigation, Power, Flood Control, Navigation etc., so that all round development of the State can be achieved with maximum economy.

(*From Power Engineer*)

(*Continued from page* 9)

Salinity of West Bengal Rivers: Effects on Pisciculture

purpose, a Board, properly constituted, is likely to prove most helpful. (*from Science and Culture*).

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Noted Hydraulic and Power Plant Expert visits India

Dr. Ing. Carlo Semenza, M.A.S.C.E., M.I.C.E. a noted Italian Hydraulics and Power Plant Engineer visited India from 7th to 18th October. During his brief stay Dr. Semenza was in Delhi, Madras, Calcutta and paid a short visit to the Bhakra Nangal Project.

Dr. Semenza is a Member of the Managing Committee of Messrs. Electroconsult, who offer the most comprehensive services for thermal and hydro power, design of dams and barrages and other hydraulic works, transmission and all other aspects of power generation. He has been working in hydraulics and power plant design and construction for 37 years and is a Central Manager of S.A.D.E. an Electric Company in Italy. Dr. Semenza was awarded the Telford Medal of the English Institution of Civil Engineers in 1952, and the "Honoris Causa" Doctorship of Munchen Technischen Hochschule in 1954. He is a Member of of the Italian Committee of International Commission for Large Dams and in 1954 was appointed an Electric Power Expert by U.N. Technical Assistance Administration.

Dr. Semenza is a promoter of the largest possible employ of the arched structures in their different types of arch, arch-gravity and dome dams ; he has done pioneering work in the solving of important problems in this field. At the recent conference of Large Dams at Knoxville Tennessee, U.S.A., Dr. Semenza's paper together with those of other exponents in this field was highly commended, and the general consensus of opinion of the meeting was that the curved dams have a great future. Also American designers, who, with only a few exceptions, for a long time have shown a marked interest in gravity dams are now increasing their considerations towards the high factor of safety and valuable economy offered by arched structures.

Dr. Semenza was very much impressed with the work of Indian Engineers and the tasks that India is doing in the field of Power and Irrigation, so similar though, obviously, in a different scale to those recently done by Italian technique ; however, he feels that the time has come now for India to adopt more advanced designs and techniques to suit her economic conditions. The adoption of modern economic designs will not only bring down the costs of the Projects, without reducing the safety factor but also considerably reduce the use of Cement and Steel, two vital commodities which shall be in short supply for some years.

Our Delhi Letter

(From our special Correspondent)

Suez Canal Clouds

The horizon of the country's development programmes has been over-cast with the difficult and adverse affects of the Suez conflagration which shot up suddenly like a frightening meteor. Apart from the tragedy that the World-War can bring to human life and health all over the globe, its influence on the construction programmes of this country is bound to be serious.

There are shipments of capital equipment contracted with various European countries on which depends the timely fulfilment of the Five Year Plan. With the supplying countries involved in a world war, their attention is bound to be diverted to military preparations and stock piling thus putting the civilian programmes into the background. The commitments made for civilian orders will definitely be put back in a lower priority.

Besides failure of targets there will be the inevitable influence of shortages which will retard the wheels of industry. The aggregate effect of all these factors makes it impossible for planners to prosecute their plans with any sense of certainty.

Effect on India's Projects

In India the effect of such a situation is going to be more serious than may appear at first sight. There will be innumerable bottlenecks which cannot be foreseen in the first review. It can be generally stated that only those projects will continue in which the element of foreign aid is minimum.

This consideration points to the desirability for the development of Indian potential in a manner in which the natural strength and resources of the country are unified to yield a self-sufficient mechanism which will enable the country to prosecute its programmes for completing the food and power projects to a stage in which there is no set back in this primary step for raising the living standards of the people.

The leaders of the country responsible for its development and prosperity have already taken counsel with the heads of departments as to what ought to be done in the case of a real emergency.

Now that the clouds of war are somewhat lifted and rays of sunshine seem to be appearing over the horizon, it is still necessary that in the future policy decisions extreme care be exercised for making the country as little dependent on foreign aid as possible. In the present age of science complete insolation is unthinkable and also undesirable. Yet the degree of dependdence of a country is an index of its weakness. Even such small countries as Austria, Japan, Germany are far ahead of India in this respect. Their standards deserve to be emulated and engineers must devote their thought and energy to the achievement of this ideal. In particular the country should lose no time in discussing and finalising priorities.

C.B.I. meet at Bombay

The Central Board of Irrigation meeting at Bombay was an unprecedented success. Apart from the fact that the routine administrative agenda was approved, the special attention of the eminent engineers gathered there was focussed on the Second and Third Five Year Plans. It is a well known fact that in these plans the Irrigation and Power Projects play a great part. Their satisfactory completion however depends on the initiative, energy and foresight of engineers.

A symposium was held on Nationwide Survey of Irrigation and Power Projects and the investigations that are needed in order to make these projects realistic. It was argued that the time is now past for generalisation and engineers have to come to brass tacks if the ambitious programme was to be fulfilled. For this purpose, the necessity of highest priority being given to the projects in the Second Five Year Plan was accepted by common consent. It was also conceded that the 3rd Five Year Plan might also be investigated without any delay. After all no big project can be investigated in less than 4 to 5 to years even if all efforts are concentrated on the work. The time left is therefore by no means liberal and really energetic action is required.

Chief Engineers must be Secretaries

For fulfilment of the engineers' objectives, it was considered that the head of a Department like Irrigation and Power must also be the head of the particular administration. If there are non-technical officers at the Head of the the Department, there is bound to be difficulty regarding the selection of projects, reaching of decisions on technical matters and their implementation in all its urgent detail. As a suitable via media, the interposition of a non-technical Joint Secretary below the Chief Engineer of a State was considered ample safeguard in favour of administrative knowledge being brought into the technical policies and decisions. This view was upheld even by a person of the eminence of Justice M.C. Chagla, who was now officiating as Governor of the State of Bombay.

Need for Research

So far as the question of encouragement of engineering research was concerned, it was held that the funds needed for meeting the requirements of fundamental as well as applied research could be only a fraction of the projects which the country is undertaking to do in the Five Year Plan. It was therefore considered that on no account should there be any stinting in the funds needed for research work. Even if some of the expenditure on research does not bring immediate results, its long term value should not be under-rated.

Unesco at Delhi

The United Nations have conferred a particular honour on India by selecting New Delhi as a venue for their important session. In this session, a real get-together between East and West has started on on an unprecedented scale so far as India is concerned. It is of particular interest to engineers on account of the fact that arid region development has been given a definite priority. In India we have the great Rajasthan desert which needs the attention of scientists and engineers in order to develop the waterless land to its full latent potentiality. This can be done if science bends itself to its solution. Even nuclear energy can be considered in the absence of water so far as the provision of power is concerned. Also there can be schemes of irrigation from tanks by means of open pumping with cheap power.

Cultural Exhibition at Delhi

The exhibition site at Mathura Road has again come to new and refreshing prominence. Although the crowds that now gather are in no way equal to the vast multitudes that used to visit a year ago, the educative and cultural value of the current year's exhibition has its own stature. The irrigation and power projects have found an important place in the exhibition and the Central Water and Power Commission and the Bhakra Dam Project have exhibited their models which are of high informative value to the public.

It is high time that this exhibition site be made permanent for the holding of exhibitions. It is a great pity to see a lot of effort invested in making up the exhibits and then complete wiping out of all that was created. It is desirable that some more planning be put into this venture, thus making it possible to conserve the maximum value of such an effort.

$ 24 Million Contract for 'English Electric

The award of a $92 million contract to an American constructions firm—believed to be the biggest 'turnkey' contract of its type ever signed in the U.S.A.—has brought The English Electric Company subcontracts for hydro-electric machinery and associated equipment worth approximately $24 million. The $12 million order recently announced by the Grant County Commissioners covering water turbines formed part of this contract.

The main contract is for the construction of a new dam and power house at Priest Rapids on the Columbia River. It has been given by Grant Country Public Utility District No.2 of Ephrata, Washington State, in the Pacific Northwest, to the internationally known construction firm, Merritt-Chapman & Scott Corporation, whose headquarters are in New York.

The Merritt-Chapman & Scott bid included English Electric water turbines, generators and transformers and a contract for this equipment, valued at approximately $24 million, has accordingly been awarded to the English Electric Export and Trading Company.

The Priest Rapids site is downstream from Grand Coulee, Chief Joseph and Rock Island Dams, but upstream of McNary Dam and immediately above the confluence of the Snake River with the Columbia River. It is one of a chain of stations being built to develop water power along the Columbia River System.

The plant to be installed by English Electric will comprise eight 114,000 h.p. water turbines and eight generators, each having an output of 83,000 kVA at 85.7 r.p.m. The output from each pair of generators will feed into a step-up transformer; five transformers (one being a spare) will be supplied by English Electric, each having an output of 183,000 kVA. They will raise the generating voltage of 13,200 volts to 230,000 volts for transmission to various consuming centres.

The Grant County Public Utility District No.2 is governed by three commissioners, Messrs. F. William Arlt, William Schempp and George Schuster, and their technical operations are under the control of their General Manager, Mr. Glenn Smothers. The whole project is under the technical supervision of the Harza Engineering Company of Chicago, Illinois, whose services have been retained by Grant County P.U.D. as consultants.

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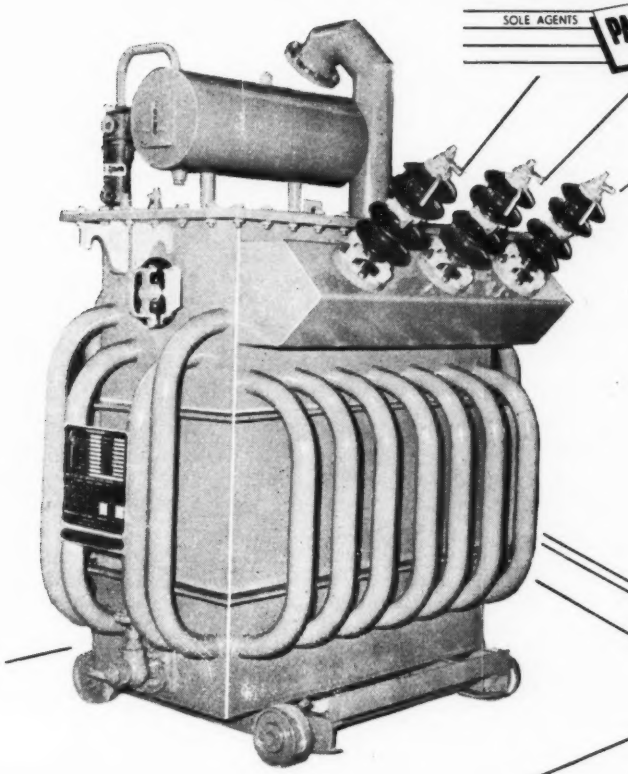

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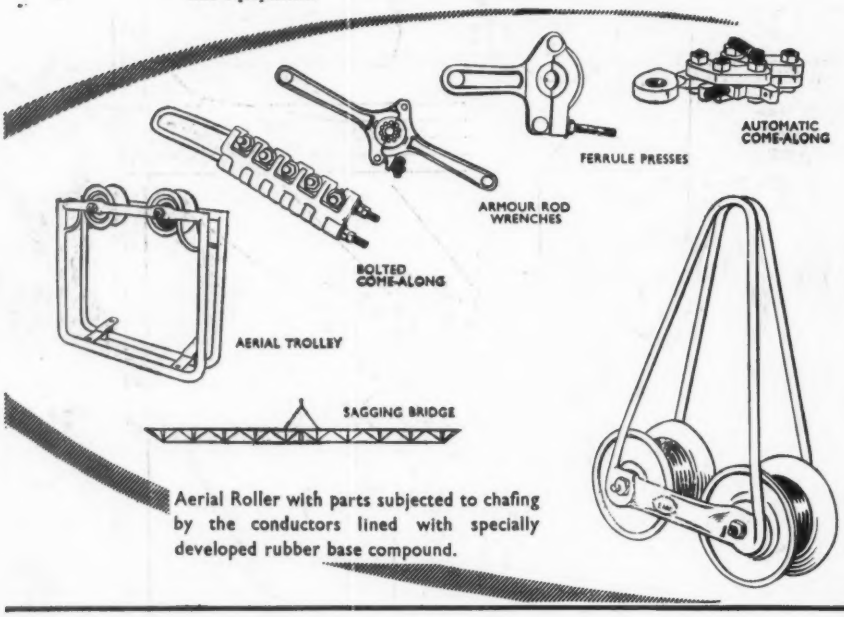

Aerial Roller with parts subjected to chafing by the conductors lined with specially developed rubber base compound.

EMC 136, Jessore Road, Calcutta 28

Representing :

ELECTRICAL MACHINES CORPN. PRIVATE LIMITED

ELECTRICAL MANUFACTURING CO. LTD.

EMC 1187